

SOME CONSIDERATIONS

Touching the
VSEFULNESSE

OF EXPERIMENTAL
Naturall Philosophy,

*Propos'd in a familiar discourse to a friend
by way of Invitation to the study of it.*

THE SECOND TOME,
Containing the later SECTION
Of the Second PART.

*By the Honorable ROBERT BOYLE Esq;
Fellow of the ROYAL SOCIETY.*

OXFORD

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THE PUBLISHER

TO

THE READER.



Hereas the Preface of the Noble Author to this *Second Tome* of the Usefullnesse of Experimental Philosophy, written with designe it should come forth a Year or

two before the last, it is fit that something be now added about the present Publication.

First, if Inquiry be made, why the *ESSAYS*, that now come abroad, are not accompanied with those others, that according to the *sorts* of the titles, should precede some of them; He represents, That it was not thought fit, that those that are now publish'd, having no necessary dependance on the rest, and being sufficiently intelligible without them, should stay for *Discourses*,

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courses, that are not at present ready, and perhaps will not suddenly be so; *partly*, in regard they consist of no small number of loose Papers, which by reason of some, yet insuperable, obstacles (of which want of health is none of the least) he cannot conveniently seek out, range, and compleat; and *partly*, because he cannot, in the place where He is now detain'd, be master of divers uncommon Minerals, and some Chymical productions, whose Descriptions through hast he omitted, because he had them at hand in the place, where those ESSAYS were written, and presumed, He could at leisure fill up those Vacancies he left for such Descriptions.

Secondly, as to the ESSAYS themselves, which, for the Reasons just now mention'd, come not abroad with the rest, though the Excellent Author hath of late years constantly refused to promise any thing to the Publick, yet that the *Reader* may the better Judge of the Scope and Designe of the whole treatise, He will not deny him an Intimation of what Subjects those ESSAYS relate unto, by telling him, That *one* of them treateth of the Usefulness of Chymistry (not to Physick, but) to the Empire of Man over the Inferiour Works of Nature: *Another*, of the Advantages that a Naturalist's Country may derive from

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from his Curiosity : *Another*, of the mutual Assistance that the Speculative and Practical part of Physiology may afford each other: After which, comes a Discourse containing inducements to hope for much greater things from *Experimental Philosophy*, than men have hitherto obtained.

Lastly, As to what the Author taketh notice of, about the Coincidence of some Experiments, that may be mentioned as well by Others as by Him ; is very possible, that the same things may, by the same, or other, ways, come to the knowledge of different persons. Besides, that I have heard Him mention with some complaint, that, when divers years since he writ several Discourses (whereof some belonged to the *Usefulness of Experimental Philosophy*,) for the Use of a private Friend, not for the Presse, he was not so shy, as had been requisite, of *showing* divers Experiments, and of imparting others in discourse, to Inquisitive men, whether English or Forreiners, that came to visit him ; divers of which things he afterwards found in print, sometimes indeed with, but for the most part without, mention of his Name. So that sometimes his unwillingness to disoblige such Writers, and to contend about such matters, made him either wholly omit some of the particulars he afterwards intended to publish, or even to *cross out* several

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several passages, that he had already written, where he would, without much inconvenience (for that did not alwaies happen) either quite leave them out, or substitute others (though less proper) in their stead. He added also, that sometimes observing his Notions and Experiments to be adscribed to other Writers, and somewhat wondring at it, he found indeed such Writers to have mention'd such things, but in *Editions* that came abroad after the publication of our Author's Writings, from whence such things might with the greater likelihood be presumed to have been borrow'd, both because some of the Writers had convers'd with *him*, and he could not find them in the *First* Edition of such Books. But these unfair proceedings being the faults but of a *few*, he said, he was far from imputing them to the *Generality* of those, that have mention'd, (which divers of those have very civilly done,) his Experiments, or writings in theirs.

The Particulars being thus taken notice of, the Curious Reader ought not to be any longer detained from conversing with the Author himself in this Instructive Treatise. Fare-well.



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HAVE, in the Preface, and Body of the former and already publish'd Part of this Treatise, taken notice of so many of the things, that concerne the whole work in General, that I presume it will not here be necessary to detain the Reader with any other Particulars, than those, that

will be offer'd by way of Answers to some Questions, that are like to be ask'd about the Publication of this Present Tome.

And in the first place, If it be demanded, why this Latter part did not more closely follow the former, I have this to Answer, That the Papers it consisted of chanc'd to be so unfortunately dispos'd of, during the late Publick Confusions, that for a great while I was not the Master of them, and in the mean while was, sometimes upon one occasion, and sometimes upon another, engag'd to venture abroad the History of Colours, the History of Cold (with the Preliminary and Additionall Tracts) Hydrostaticall Paradoxes, and the Origine of Formes and Qualities; the Publication of which Treatises, besides that of some Anonymous Papers, as it took up much of the time I had to spare for the Presse, so it may, I suppose, keep it from being thought strange, that I did not trouble

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ble my selfe and others with this Book also. And indeed, this having been (as the scope and divers Passages of it sufficiently intimate) one of the first I wrote to the Gentleman I call Pyrophilus, I had afterwards occasion, whilst it was out of the way, to make use of so many of the Experiments and Observations, that belonged to it, that fearing I had thereby too much robb'd and disfigur'd it to leave it any way fit for Publick view, I had the greater Temptation to neglect the looking after it.

But if it be further demanded, why then, since it was not ready to come out more early, I did not condemn it not to come out at all? I have two things to returne by way of Answer.

The first is, That some Eminent Virtuosi, to whom I owe a peculiar Respect, were pleas'd to challenge the Edition of this Tome, as if I had made my selfe a Debter to the Publick for the Second Part of this work, by having (suffer'd what I wrote to a private Friend to be divulg'd in the first. Especially since the Publick had given that so very favourable an Entertainment; as besides other things, the Early reprinting of it manifested.

The other part of my Answer, and that which made the former Consideration prevalent, is, that I was overcome either by the Reasons, or by the Authority, of those Ingenious Persons, that were pleas'd to think, that this work would not prove unservicable to Mankind, to whose good, both as a Man, and Christian, I have been long Ambitious to contribute, as well upon the account of the Great Author and Divine Redeemer of Men, as of that common Nature whereof all men partake. What the Utilities of this work were conceived to be, the Reader will find disclosed at the end of this Preface. To which I will therefore referre him for an Account of them, and now only take notice, that as to one of the scruples I had against the Publication, namely, That I had plunder'd this present Treasure of divers Particulars; wherewith I had accommodated
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Some of my other Writings, I could not well reject this Answer, that in so many years as had passed since the writing of this Book, I had not been so negligent a Commerfer with the works of Nature, and Art, as not to be able to make some amends for what I had taken away, and easily substitute other Experiments, and observations, to supply the vacancies left by those I had transferred to other Discourses.

And as to another of my scruples about venturing abroad this Tome, namely, that it must come forth so late, if it should come forth at all, it was answered, That it could scarce come forth more seasonably to recommend the whole Designe of the Royal Society, whose generous aimes being to promote the knowledge of Nature, and make it usefull to humane Life. This Treatise may procure them some number of Assistants in a worke, whose Vastnesse and Difficulty will need very many, if mens Curiosity and Industry can by this Treatise (or any in the like Purpose) be well excited by a Conviction of the reall and wide disparity betwixt true Natural Philosophy, & that of the Peripatetick Scholes, and that in cultivating the former, they will not meet with a field that will afford them nothing, but (the wonted Production of the Latter) the Thornes and Thistles of acute indeed, but uselesse, and oftentimes troublesome, Subtletyes; but that they may expect a Soyle that may by adue Culture be brought to afford them both Curious Flowers to gratifie their Curiosity, and delight their senses, and Excellent Fruites, and other substantiall Productions to answer the Necessities and furnish the Accommodations of Humane Life.

And I will not deny, that I have had the fortune to be looked upon, as not the unfittest Person in the World to offer something in this kind, For those that are meer Scholars, though never so Learned and Criticall, are not wont to be acquainted enough with Nature and Trades, to be able to suggest those Instances, that are the most proper to manifest that, which men are to be convinced

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convinc'd of. The meer Chymists, besides that their Curiosity in wont to be too much confin'd to let them be fittest for such a work, have the ill fortune to be distrust'd by the Generality of men, not Credulous, which is a great unhappinesse in this case, because that though their Experiments were never so true (as divers of them are) yet skill in their Art being requisite to make them, mens diffidence of the Proposers, joyned with the difficulty of examining the things, will not allow them, either to Believe what is proposed, or to Try it. And as for the New Philosophers (as they call them) though, if they were to write but for Philosophicall Readers, I know several of them, that would questionlesse do it rarely well; yet the generality of those Readers to whom we would give good Impressions of the study of Nature, being such as will probably be more wrought upon by the Variety of Examples, and Easy Experiments, than by the deepest Notions, and the neatest Hypotheses, such a Treatise for the kind, as that which follows, containing many Practises of Artificers and other Particulars, that are either of easy Tryal or immediate Use, may perhaps by that Variety gratifie, and perswade a greater number of differing sorts of Readers, than a farre more Learned and Elaborate Piece, that might be welcomer to more intelligent and Philosophicall Perusers.

If it be askt by Some that know me, Whence it comes, that the Second part of the Usefullness of Experimental Philosophy being written (as very credible Persons that saw it can witness) about the year 1658. there may be met with in the following Treatise some Experiments of my owne, that they know were since made, and some (though few) Citations out of Books publisht since that time? If I say this be askt, the Answer is intimated a little above; For having transferr'd to other Tracts many passages that belong'd to these I now publish, I was oblig'd to repaire the injury I had done them, by supplying them with such Particulars as

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offer'd themselves to my memory when I hastily review'd this
Tome, without scrupulously minding the times, when the
Particulars inserted did first occurre. And if this Adver-
tisement be apply'd to some other of my Writings, that ei-
ther the importunity of Friends, or some unwelcome Acci-
dents, engag'd me to publish out of their due time, and not
in their intended order, it may keep men from thinking,
that when I first wrote them, I had read over, or at least
seen, (which indeed I neither did nor could) every Book
of a recenter Date, of which upon occasion I mention a
Passage or two, and those perhaps as they are cited by other
Authors, we being here in England but slenderly and very slowly
furnish'd with modern forreign Books.

All these inserted passages the Reader should find included
in Paratheses (as the Printers call these marks []) by which
he will yet be able to distinguish severall of them, though I
now find, that some others by the negligence of the Transcribers
or of the Press or of Both have bin omitted, which Advertise-
ment I feare may have need to be extended to some other prin-
ted Tracts of mine, wherein Paratheses are to be met
with.

Bating these few additionall passages, the insuing Booke
comes forth without taking notice of what changes or disco-
veries have happened in the Common wealth of Letters, since
the time it was written in. On which account, if some few of
those many particulars deliver'd there shou'd chance to be co-
incident, with what some other man hath written, I would
neither on the one side be thought a Plagiary my self, nor on
the other side deny any man, to whom it may be due, the honour
of the earliest Publication, though, to shun needless Contro-
versies, I am somewhat shy of naming this or that Person, as
the first Proposer or inventour of an experiment, which (especi-
ally if the persons or things be not considerable) is often diffi-
cult enough to discover, witness the contests that have bin, and
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yet continue, about the first Inventors of Common weather-glasses, the Ascension of water in slender Pipes, the glass drops that fly in pieces, the measuring of time by a Pendulum which is more strange, the art of Printing it self. If it be ask'd why I did not forbear to make use of some Practises of tradesmen and other known, and perhaps seemingly triviall, Experiments. These things may be replied,

1. That since on divers occasions it was requisite, that my discourse should tend rather to convince than barely to inform my reader, it was proper, that I should imploy at least Some instances, whose truth was generally enough known, or easy to be known (by making inquiry among Artificers) even by such as out of laziness, or want of Skill, or accommodation cannot conveniently make themselves the tryals.

2. But yet, I have taken care, that these should not be the only, nor yet the most numerous instances, I make use of: it being in this Tome, as well as in my other Physiologicall writings, my main businesse, to take all just Occasions to contribute as much, as without indiscretion I can, to the history of Nature and Arts.

3. As to the Practises and observations of Tradesmen, the two considerations already alledged, may both of them be extended to the giving of an account of the mention I make of them. Of the truth of divers of the Experiments I alledge of theirs, one may be easily satisfied by inquiring of Artificers about it, and the particular or more circumstantial accounts I give of some of their experiments, I was induc'd to set down by my desire to contribute toward an experimental History. For I have found by long and unwelcome experience, that very few Tradesmen will and can give a man a clear and full account of their own Practises; partly out of Envy, partly out of want of skill to deliver a relation intelligible enough, and partly (to which I may add chiefly) because they omit generally, to express either at all or at least clearly some important

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variant circumstance, which because long use hath made very familiar to them, they presume also to be known to others: and for the omission of such circumstances, doth often render the Accounts they give of such practices, so darke and so defective, that, if their experiments be any thing intricate or difficult (for if they be Simple and easy, they are not so liable to produce mistakes) I seldom thinke my self sure of their truth, and that I sufficiently comprehend them, till I have either tryed them at home, or caused the Artificers to make them in my presence.

They that have given themselves the trouble of endeavouring to make the experiments of Tradesmen, to be met with in the writings of Cardan, Weckar, and Baptista Porta for instance, and have thereby discovered (what is not usually obvious upon a transient reading) how lamely and darkely, (not to add unintelligibly) severall things are written, will probably afford me their Assent, having found upon tryal the instructions of such learned and ingenious men, to be often obscure and insufficient for practice.

But here I must give the reader notice, that as Mechanical Artes for the most part advance from time to time towards perfection, so the Practices of Artificers may vary in differing times, as well as in differing places, as I have often had occasion to observe. And therefore I would neither have him condemn other writers or Relators, for delivering accounts of the experiments of Craftsmen differing from those I have given, nor condemn me, for having contented my self to set down such Practices faithfully, as I learn'd them from the best Artificers (especially those of London) I had opportunity to converse with.

But here perhaps it will be demanded by way of objection, whether I doe not injure Tradesmen by discovering so plainly those things, which our Laws call the Mysteries of their Arts. This question, that may perhaps by some be clamorously pressed,
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not only upon me, but much more upon Some ingenious men of our Nation, whose pens have bin more bold than mine in disclosing Craftsmens Secrets, 'twill be requisite to return severall things by way of answer, but that such Readers as are not troubled with the Scruple, may not be so with the Apology, they will find this printed in another character, so that, if they please, they may pass it over unread.

First then, It may be represented, that I never divulge all the Secrets and practices necessary to the exercise of any one Trade, contenting my self to deliver here and there upon occasion some few particular Experiments, that make for my present purpose: So that, for much more than I allow my self to doe, I can plead the example, not only of other writers, that have published Books to teach the whole Mystery of this, or that trade, as the Priest *Antonio Neri* hath diligently done in his Italian *Arte Vetraria*, and some English, as well as forreign, Virtuosi have done on other Subjects; But also some of the Artificers themselves, as the famous Gold-smith and Jeweller *Benvenuto Cellini* in his much esteemed Italian Tracts of the *Lapidaries* and *Goldsmiths Trades*. Thus also the famous Mineralist *Georgius Agricola* published in Latin a whole Volume of the more practical part of Mineralogie, wherein he largely and particularly describes Experiments, tooles, and other things that belong to the Callings of *Mein men*. To which I might add divers other Treatises, some of them French, others Italian, (which, though I could not procure them, I have seene among curious collections of books) that have bin published about Severall Artes by the Artificers themselves. And 'tis notorious, that in English, as well as in divers forreign languages, we have Books of the Artes of Gunnery, Distillation, Painting, Gardening &c.

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be divulg'd by persons, that Professed those Callings.

Secondly, it is not the Custome of Tradesmen to buy Books, especially such as are not intended for such Readers, and treat (for the most part) of things either beyond their reach or wherein they seem not likely to be concerned; And as for Gentlemen and Scholars, though some of them may, to satisfy their curiosity, make a few tryalls, yet their doing so will scarce in the least be prejudicial to Tradesmen. Since (to omitt other Arguments) it will not be worth while for a Virtuoso to be at the charge and trouble of buying tooles, and procuring other necessary accommodations to sell a few productions of his skill, though he should not scruple to descend to such a Practice. For if he make but a small number of Experiments, their effects will cost him more than the like may be bought for, of those that make them in great Quantities, and whom their trade obligeth to be solicitous to buy their instruments and materialls at the best hand, and sell them to the best profit. Besides that most of the workes of Artificers, are chiefly recommended to the more curious sort of buyers by a certain politenesse, and other ornaments (comprised by many under the name of *Finishing*) which require either an instructed and dexterous hand, or at least some little peculiar directions, which I did not allwayes thinke my self oblig'd to mention, in a treatise designed to assist my friend to become a Philosopher, not a tradesman, and publish'd to help the Reader to gain knowledge not to get money.

Thirdly, to publish an Experiment or two, or in some cases a much greater number belonging to a Trade, is not sufficient to rob a Tradesman of his Profession. For, besides that most trades consist of Severall parts, and are each of them made up of divers Practices (that commonly are more than a few) Those numerous Mechanicall Arts,

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that are called handicrafts, require (as their very name argueth a Manuall dexterity) not to be learnt from Bookes, but to be obtaind by imitation and use. And to these considerations I shall add this more important one, that Mechanicall professions are wont to be as it were made up of two parts, which, for distinction sake, I take leave to call the *Art* and the *Craft*; by the former whereof I mean the skill of making such or such things, which are the genuine Productions of the Art, (as when a Taylor maketh a suit, or a cloak,) and by the latter I mean the result of those informations and Experiments, by which the Artificer learns to make the utmost profit, that he can, of the Productions of his Art. And this Oeconomical Prudence is a thing very distinct from the Art it self, and yet is often the most beneficial thing to the Artificer, informing him how to chuse his materialls and estimate their goodnesse and worth, in what places, and at what times, the best and cheapest are to be had, where, and when, and to what persons the things may be most profitably vented. In short, the Craft is that which teacheth him how both to buy his materialls and tooles, and to sell what he makes with them to the most advantage.

Fourthly, it may often prove more advantageous than prejudiciall to Trademen themselves, that many of their practices should be known to Experimentall Philosophers.

* The Essay here meant is that which treats of the Utility of the Naturalists insight into trades.

This I suppose that I have sufficiently proved in some, and especially in * one of the following Essayes.

Yet I shall now represent, that though some little inconvenience may happen to some Trademen by the disclosing some of their Experiments to practicall Naturalists, yet that may be more than compensated, partly, by what may be contributed to the perfecting of such experiments themselves, and, partly by the diffused Knowledge and sagacity

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capacity of Philosophers, and by those new Inventions, which may probably be expected from such persons, especially if they be furnished with Variety of hints from the practices already in use. For these Inventions of ingenious heads doe, when once grown into request, set many Mechanical hands a worke, and supply Tradesmen with new meanes of getting a livelyhood or even enriching themselves. As to the discipline subordinated to the pure Mathematicks, this is very Evident, for those speculative Sciences have (though not Immediately) produced their trades that make Quadrants, Sectors, Astrolabes, Globes, Maps, Lutes, Vials, Organs, and other Geometrical, Astronomical, Geographical, and Musical instruments; and not to instance those many Trades, that subsist by making such things as Mechanicians, proceeding upon Geometrical Propositions, have bin the Authors of; we know that whether the excellēt Galileo was or was not the *first* finder out of Telescopes, yet he improv'd them so much, and by his discoveries in the heavens, did so recommend their usefullnesse to the curious, that many Artificers in divers parts of Europe have thought fit to take up the Trade of making prospective glasses. And since his death, severall others have had profitable worke laid out for them, by the newer directions of some English Gentlemen, deeply skill'd in Dioptricks, and happy at Mechanical contrivances; in so much that now we have severall shops, that furnish not only our own Virtuosi, but those of forrein Countreyes with excellent Microscopes and Telescopes, of which latter sort I lately bought one (but I confesse the only one that the maker of it, or any man, that I hear of, hath perfected of that bignesse) which is of threescore foot in length, and which the Ingenious Artist, that made it Mr Reeves, prized constantly at nolesse than an hundred pounds (English mony) I know

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not, whether or no I should add, that possibly some particular experiments of mine have not bin hitherto unprofitable to severall Tradesmen: But this I may safely affirm, that a great deal of mony hath bin gained by Tradesmen, both in England and elsewhere upon the account of the scarlet Dye, invented in our time by Cornelius Drebbell, who was not bred a Dyer nor other Tradesman. And that we dayly see the shops of clockmakers and watchmakers more and more furnished with these usefull instruments, *Pendulum Clocks*, as they are now called, which, but very few years agoe, were brought into request, by that most ingenious Gentleman, who discovered the new Planet about Saturn.

I have handled the Subject of the foregoing Arguments much more particularly, than I would have done, had not my pen bin draw'n on, by a Hope that the things I have represented may furnish Apologies to many inquisitive men, who may be thereby embolden'd to carry Philosophical materials from the shops to the Scholes, and divulge the experiments of Artificers, both to the improvement of trades themselves, and to the great enriching of the History of Arts and Nature.

If it be further demanded, whether I have furnished these Essayes with the chiefest things I could have afforded them, I must confesse, that I have not, for though I had tying by me Severall Experiments and observations, less inconsiderable than many of those I have made use of, which would have bin pertinent enough to the Subjects here treated of, yet I purposely forbore to imploy them in these tracts, because I would not defraud those others, to which they were more proper, & some of them necessary. For I freely declare, that my designe in this present Tome was not to furnish it as well as I could,

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but to preserve, as in a repository, several scatterd Experiments and Remarks, which I could best spare from the other Treatises I had design'd, which might otherwise probably be lost; but yet I shall not deny, that I did not carelessly draw up some of the following Tracts, but that I endeavourd to write them in such Methods, that they might contain severall distinct heads, and those as comprehensive as I could easily make them, that both the young and hopefull Gentleman I call Pyrophilus, and I my self might conveniently refer such other practices and experiments (especially those of Tradesmen) as should hereafter occur to us, and appear to belong to those heads. And I did the lesse despair of his giving a kind reception to these discourses, because I could expect so little assistance in my undertaking, having never met with any booke, great or small, written upon the subject I was to treat of.

If hereupon it be objected, that by my own confession, divers of the particulars admittid in to this Booke are but slight, and some of them already known, I shall represent, that as some of the Experiments spoken of are but slight, so there are others, that possibly discerning Readaers will not thinke to be altogether such, and that 'twas fit (for reasons already mention'd in this very preface) that I should not forbear to imploy, as proffes to convince others, things either known or easy to be made so, especially since I commonly use them to some purpose or other, whereto they have not been applyed, and my design in the publication of these trisles being chiefly to invite the generality of Readers, though of different inclinations, Qualities, &c. to addict themselves to the study of experimental Philosophy. The variety and easiness I have aim'd at in the experiments I have set down, may for ought I know, be more proper, than if I had confin'd my self to the mention of a few choise and Elaborate experiments, which some Readers would think impertinent to their studies,
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and others judge too difficult for them to put in practice. It appear'd not unfit, that a book, whose title was like to procure it very different sortes of Readers, should be for the most part written in a popular way; divers persons, especially those of a higher Quality, by a trifle that hath the luck to gratify their curiosity, may be more successfully invited to relish and esteem experimental learning, than by a deep notion, or a weighty experiment. And there are others that will easier be brought to value and try experiments, by meeting with some few, though but slight ones, that happen'd to suit with their humour or calling, or to accommodate them on some particular occasions, than they would by many others, much more luciferous, or otherwise important. And though it were to be wished, that mens Kindnesse to Practicall Philosophy were groundd on the best motives, yet this Treatise will not altogether miss the Aim of its Publication, if even upon the foremention'd Slighter Accounts, it engages Readers to make as well as relish experiments; for the pleasantness, variety, usefullness and other indearing Qualities of such an employment, will probably invite most of them to a further progress, whereby many usefull Phenomena and observations are like to accrew to what is already known of the History of Nature and Arts. And if this shall come to pass, it will keep him from complaining of Labor lost, who in venturing upon such a worke as now comes forth, was knowingly to postpone the appetite of fame to the Desire of doing some service to mankind; to which end he takes on of the directest wayes to be the contributing some what to the Advancement of Experimental Philosophy.

It remaines, that I add something more, which possibly may not a little befriend both these last mention'd Answers, and severall others contain'd in this preface, for, when all the former demands occur'd to my thoughts, as likely to be made, some by one sort of Readers, and some by another, those

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virtuosi, that were solicitous for the Publication of these Papers, were not backward to urge the utilities, which they fancied would thence accrew to the publique. And I cannot very well deny, that, as meanly as I thinke of a Treatise to whose first Tome I did not, till the second Edition, (when I could conceal it no longer) let my name be prefixt, yet such a worke as this for kind well perform'd, may be a very usefull one. And even of this following book, such as it is, it was suggested, that the uses would not prove despicable, in regard that beside those, that are common to it with the formerly published Tome, such as the improvement of the minds of men, and (especially) the assisting them to understand the Workes of God, and thereby engage them to admire, praise and thanke him for them. Besides these (I say) there may be other uses of the following Tome, which, to avoid increasing a prolixity that I feare is already too great, I shall rather name than discourse of, contenting my self briefly to intimate, that 'twas conceiv'd the peculiar uses of this present Tome might be such as these.

I. It may afford Materialls for the History of Nature, which that it may the more plentifully do, I have purposely on severall occasions added a greater number of Instances, than were absolutely necessary, for the making out of what I intended to declare or prove.

II. It may afford some Instructions, Advices, and Hints to promote the Practicall or Operative part of Naturall Philosophy in divers particulars, wherein Men have been either not able, or not solicitous to assist the Curious.

III. It may enable Gentlemen and Scholars to converse with Tradesmen and benefit themselves (and perhaps the Tradesmen too) by that conversation; or at least, it will qualify them to ask questions of Men that converse with Things; and sometimes to exchange Experiments with them.

IV. It may serve to beget a Confederacy and an Union
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between parts of Learning, whose possessors have hitherto kept their respective Skills strangers to one another; and by that means may bring great Variety of Observations and Experiments of differing kinds into the Notice of one man, or of the same persons; which how advantageous it may prove towards the Increase of knowledge, our Illustrious Verulam has somewhere taught us.

V. It may contribute to the rescuing Naturall Philosophy from that unhappy Imputation of Barrenness, which it has so long lain under, and which has been, and still is, so prejudicial to it. And to effect this Rescue, it will in some measure enable those that desire it to employ those practick Arguments, that are proper to convince many that are not to be convinc'd by any other sort of Prooves.

VI. And which is the main of all, it may serve by Positive Considerations, and Directions, to rouse up the Generality of those, that are any thing Inquisitive, and both loudly excite and somewhat assist the Curiosity of mankind; from which alone may be expected a greater progress in Usefull Learning, and Consequently greater Advantages to men, than in the present state of Humane Affairs will be easily imagin'd.

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OF THE
VSEFULNESSE
OF
Experimental Philosophy.

The SECOND PART.

The SECOND SECTION.

Of its Vsefulness to the *Empire of*
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ESSAY I.

Containing some general Considerations about the Means, whereby Experimental Philosophy may become useful to Humane Life.

Hitherto, my Dear *Pyrophilus*, I have attempted to satisfy You of the Usefulness of Experimental Natural Philosophy to Physick: it followes, that I proceed to endeavour to shew you, that it may be also very serviceable to Husbandry, in all its subordinate parts, and to those other Professions that serve to provide Man with Food or Rayment, or do otherwise minister to the Necessities or Accommodations of Life; as the Trades of Brewing, Baking, Fishing, Fowling, Building, and the rest not needful here to be enumerated. For though the Humane Body, in respect of the Rational Soul, (which is the Inventress and Seat of Sciences) be one of the Corporeal things, over which the Empire of Knowledge is to be establish'd; yet taking Man as a Creature made up of Body and Soul, the Advancement of his Empire seems to consist more properly in the Inlargement of his Power over the other Creatures: Physick seeming rather to defend him against Revolts and Insurrections at home, than to increase his Power, and extend the Limits of his Empire abroad.

But, *Pyrophilus*, I hope You do not expect, that I should now *insist* on each, or so much as on any of the above mention'd Trades, by whose intervention tis, that Man exercises his Dominion over external Bodies. For such a work would

require little lesse than an Age, and much more than a Volume; and besides (that it is vastly disproportionate, both to my slender stock of Mechanical skill, and to the little leasure I have to conclude this Section in) I could not acquaint you with all that I could pertinently enough deliver about these matters, without too much defrauding some other Treatises that I design You: and therefore I hope you'll be content, if, in the remaining part of this Tract, I do *not only* present you a not despicable number of Considerations proper to manifest *That*, and to intimate *How* Experimental Philosophie may be of great Use to the promoting of Mechanical Arts and Trades, *but* illustrate and confirm all, or most of those Considerations by particular Instances, deriv'd from Observations and Experience.

This I shall, God assisting, endeavour to do in the following Essays. But before I descend to particulars, it will be expedient in this place to premise some general Considerations relating to the influence of Experimental Philosophie upon Trades, and two or three Advertisements, that concern the ensuing Discourses.

THE I. SECTION.

First then, to make it probable, that a true insight into Natural Philosophie may be capable of affording some reformation, or other kind of improvement to Trades, I shall desire You to consider, That being, for the generality of them, conversant about some few particular productions of Nature, such Men as are thoroughly skill'd in her general Laws, and acquainted with a vast number of her Productions, and vers'd in the wayes of applying Nature and Art jointly to several purposes, according to the several Exigencies of things, such sagacious persons (I say) will, in all likelihood, be able some way or other, to meliorate the Inventions

ventions of illiterate Tradesmen. As the Husbandman's skill, for instance, consisting chiefly in the Observations of the Nature of a few Plants and Animals, their relation to such and such Soils and kinds of Culture, and the Operations of Stars and Meteors upon them, which are Subjects that properly enough fall within the cognisance of the Naturalist, it cannot seem improbable, that He that has seriously and industriously enquir'd into the Nature of Generation, Nutrition, and Accretion, both in Plants and Animals, and knows how to vary an useful Experiment, when once found out, so as to remedy the inconveniencies, or supply the deficiencies, or improve the advantageousness, or transmute and apply the use of it, and (in summe) He that can knowingly and dexterously manage, what his own and other mens Observations have afforded him, will be able to cultivate the ordinary Husbandman's skill with as much improvement, as that confus'd skill enables the Husbandman to cultivate his Ground.

THE II. SECTION.

TO carry on the foregoing Considerations a little farther, I will adde, That it may as well conduce much to the manifesting how much Trades are subordinate to Natural Philosophie, as to the improvement of Trades themselves, that it be attentively consider'd, what things each particular Trade is, as it were, made up of. As, for Example, the chief things in the Refiners Trade are, *To* know the wayes of making, and the Operations of *Aqua fortis* upon Silver, Gold, and Copper; *to* know how to purge that *Menstruum*, that it may dissolve no Gold, nor precipitate any of the Silver it dissolves; *to* know what proportion there ought to be dissolv'd in it; *to* know with what quantity of Water to weaken the Solution, and *how long* Copper-plates need lye
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in it, to precipitate all the Silver out of it, *to know how* Lead is to be colligated with them, and *what proportion* of it is necessary and sufficient to carry off with it (when tis blown off upon the Test) the baser Metals; *to know how* to make Cupples of several sorts and sizes, and upon them *to draw off* the Lead or Antimony from the Silver or Gold, and discern when the Metal is sufficiently refin'd; *to know* what proportion of Gold and Silver is requisite for the making of *Water-Gold*, as they call it, (because it is separated from Silver by *Aqua fortis*, which dissolves this Metal, and leaves the other in a fine powder;) These things, to which many others are subservient, belong to the Refiners Trade, which, though understood by few, seems to be a very narrow and simple Trade, in comparison of a hundred others, whose Operations are far more numerous and complicated. Now if all Trades were judiciously resolv'd (if I may so speak) into the several parts they consist of, it would, I question not, manifestly appear, that the most, if not all of them, are in many particulars but *Corollaries* deduc'd from some particular Physical Observations, or but Applications of them to the uses of Humane life.

And if this be so, you will not, I presume, think it unlikely, that by a farther discovery of the Nature of those particular Bodies wherewith the Trade is conversant, and a solid knowledg of those Laws of Nature, and those Operations of Bodies upon one another, which it imployes, some, if not most, of those parts, whereof the Trade may be conceiv'd to be made up, may be reform'd or better'd, which is enough to make the Philosopher an Improver of the Trade, which he may become upon such unobvious accounts, that perhaps it may not unreasonably be hop'd, that even the Chymist's Charcoal may be made by a good Naturalist equivalent to an excellent Compost for Land. For if it be true, as well as tis probable, not onely that the Food of those Animals (as

Oxen,

Oxen, Sheep, &c.) which the Husbandman deals with, springs out of the Ground; but that the Plants, which afford them this food, are themselves nourish'd by a certain vegetative Salt they find in the Ground; and that this Salt being by frequent Seminations exhausted, the Soil grows barren, either by the Air, or the Steams of the subterraneous parts, or the spontaneous Maturation of the Saline Rudiments contain'd in the Ground, or by adventitious Manure, or by all or diverse of these together, it be re-impregnated with a new vital Saltneffe: if these things be true, I say, then those Chymical Experiments, that conduce to discover to us what kind of Salt that is, and to what other Salts it is allied or opposite, as tis to several Acid ones, may probably afford very useful Directions to the Husbandman towards the meliorating of his Land, both for Corn, Trees, Grass, and consequently Cattel. And having had the Curiosity to distill some Earths, some Dungs, and some Seeds, and observe the Salts abounding in the Liquors yielded by them, (of which we have elsewhere occasion to speak) we found cause to wish, that Experiments of that nature, in relation to the improvement of Husbandry, might be industriously prosecuted by Naturalists. He that has observ'd those many particulars in Husbandry, which might invite that great Naturalist Sr. F. Bacon (who yet mentions very few of them) to pronounce that Nitre is, as it were, the life of Vegetables; he that observes how conducive that fertilizing Dung of Pigeons is, both to make Earth fruitful to the Husbandman, and to impregnate it with Nitrous Salt for the Salt-petre man; and he that knows that moist fat Earths, so defended from the Rain and Sun, that the one may not draw up, nor the other wash down the Embrionated Saltneffe of them, will after a time abound in Nitrous Salt, if they are not permitted to spend any in producing of Vegetables;

such

Verulam Hist. v. & Mort. pag. 237. Certissimum est quancumq; terram, licet param, neq; Nitroſis admixtam, ita accumulata & lectam, ut immunis sit Solis, neq; emitat aliquid vegetabile, colligere etiam satis copiose Nitrum.

Nat. Hist. Cent. 5. Exp. 444.

such a one, I say, will perchance be apt to think, that Enquiries into the Nature of Salt-petre may be of great concernment to Husbandry. And to give you, *Pyroph.* some Inducements to expect that Chymistry may be very useful in such kind of Enquiries, I shall here mention to You a couple of my Experiments relating to Nitre.

The first is that, whereby I endeavour'd to give an inquisitive Person hopes, that Materials which seem'd unlikely, might, by due changes, and without much Art, be turn'd into Salt-petre. The Experiment was this. I caus'd some Earth to be digg'd up just underneath the Clay-floor of a Pigeon-house, such Earths being believ'd to abound the most with Nitre, that needs onely to have its Particles brought together and united to compose Salt-petre; a pretty quantity of this Earth being put into a Retort, and distill'd with a good fire *ex Arena*, afforded me though little or no Oyl, yet a pretty quantity of a reddish Liquor, which, instead of being, as others would have expected, of an acid Nature like Spirit of Nitre, was fit for my purpose, by strongly participating of the Nature of Volatile Salts; as appear'd, not onely in that I could without rectifying it, turn Syrup of Violets with it immediately green, and precipitate a Solution of Sublimate into a Milky substance: but because there came over with the Spirit into the lower part of the Receiver, a Salt in a dry form, which not onely was in Taste not unlike other volatile Salts, but was so far from being of an acid Nature, that with an acid Menstruum it readily fell to hussle, and made an Ebullition. So that it seems (which in an Enquiry about Nitre is very considerable,) that a Salt, very repugnant to Acids, may, by the Operation of the Earth and Air, be so alter'd, as afterwards by a slight management to afford Salt-petre, whose Spirit is highly acid. But of this Experiment I may hereafter make farther mention.

The other, (which we elsewhere have occasion more particularly to take notice of with Reflections on it) is briefly this. We took Pot-ashes, which you know contains but the Salt of burnt Vegetables, and on those, first dissolv'd in a little fair Water, we dropt *Aq: fortis* (whose Saline part consists indeed of little else than the Spirits of Nitre,) till all Ebullition and Hissing betwixt It and the resolv'd Pot-ashes were perfectly ceas'd; and having filtrated this Liquor, and set it in an open Vessel in a gentle heat to evaporate, it did within two or three dayes after, (and sometimes, for we made it more than once, even in a few hours,) being remov'd to a cold place, afford us very pure Chrystals of Salt-petre, as both their shape, and flashing (on live Coals) into a blew halituous flame, inform'd us. And since I have had occasion to mention the Use of Salt-petre in Husbandry, I shall not forbear to adde, That the knowledge which the Naturalist, as a discerning Chymist, may give the Husbandman of the natures and distinctions of Saline Bodies, may be of no mean use to him, by assisting him to discern and observe the considerablest differences of the various Saltnesses to be found in Soiles, and what sort of Saltness each particular Seed or Plant most affects. For by this means, not onely many Grounds might be made useful, which are thought barren, onely by reason of our not knowing for what Plants the Saltness predominant in them may be proper, but the same Ground may yeild much frequenter Crops than commonly it doth, when it is successively sow'd onely with one sort of Seed, by the due alteration of Plants delighting in the several sorts of Salts, to be met with in that Ground, which oftentimes, by being impoverish'd, or rather freed from one sort of Salt, doth but the more plentifully feed those Plants that delight in another: which in some places we have observ'd that Husbandmen seem to have taken notice of already, by sowing (in fields too remote from their Dwellings to have

Compost brought to them) Turnips, to fit the Ground for Wheat, and serve for a Manure, though in this method some other Circumstances may possibly concurr with the nature of Turnip-feed, to the preparation of the Ground for Wheat. And I am prone to think, that there is scarce any Ground or Soile, (except perhaps meer Sand) that might not, even without much Culture, be made fertile, or at least kept from being altogether barren, if we were on the one hand skill'd in the wayes of discerning the Nature of the Ground; and on the other hand acquainted with, and provided of, all the variety of Seeds and Plants that Nature has (though not all in one Countrey) afforded us. For there are divers Soiles, which here in *England*, or in other Regions, are, as uselesse, left quite uncultivated; which, Seeds or Plants, that abound in other Countries, and would probably be made to grow in these, would make serviceable to the Husbandman. Many steep and abrupt portions of Ground (some of them very large) expos'd to the Southern Sun, are left altogether waste, not onely in *England*, but in divers hot Climates, where the planting of Grapes for Wine is not yet in use; though such pieces of Land in *France* and *Italy*, and (as I have observ'd) even in the *Rhetian* Alpes, nourish excellent Vineyards.

I know an ancient and Landed Gentleman, who communicated to me upon his own knowledg an experienc'd way of making Wheat grow and prosper well on meer Clay, where there was no Grain at all did thrive: which though I have not hitherto had opportunity to try, yet upon the credit of a Person so sober and qualified, I scruple not to mention it here, because the Art consisting mainly in the Imbibition of the Seed for a determinate time in a certain express'd Oyl that is not dear; it may make it probable, that without altering the whole Soile by Manures, a slight, but convenient change made in the Seed it self, may serve to make them fit

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for one another. And (to adde that upon the by) to shew that the particular dispositions of some sorts of Seeds may enable them to make the Ground they are sow'd in, much more productive than it would otherwise be, I shall relate to you, that being not long since in the Company of a Learned and Curious Traveller, I saw, among some Rarities of a quite other nature, an Ear or two of Corn, not much unlike our common Wheat, at which being somewhat surprized, I askt him what peculiarity had procur'd that Grain admission among such Rarities? To which he replied, That in the warmer Region where he begg'd it of a *Virtuoso*, one of those Grains would afford so vast a multitude, as he was almost ashamed to name, and I am more than almost afraid to repeat: but before I went out of the house, an English Gentleman, that had a more than usual Curiosity for such kind of Trials, assur'd me, that having obtain'd some Grains of that Corn, and carefully sow'd it in some Land of his own, not far from the place we were in, he had out of a single Grain several Hundreds; though not near so many of them, as the other Traveller, who yet was a very sober and judicious man, related to have been produc'd in a better Climate and Soile. Of this strangely prolifick Wheat, the Gentleman readily granted me a promise of a sufficient quantity to make a Trial, whereof, when I shall have receiv'd it from a Servant of mine in the Countrey, You may command the Success. And this brought into my mind what I read in the Learned Jesuite* *Acosta*, who affirms, that in divers parts of *America*, where tis known that our *European* Wheat prospers not, the *Indian* (or, as many *English* have stil'd it, *Virginian*) Wheat they call *Maiz* does so wonderfully thrive, that although the Stalk bear often more than one Cluster, and the Grain be big; yet in some Clusters he has reckon'd seaven hundred grains: to which he addes, *That it is not strange in those countries to gather three hundred (Faneques, or) measures for one*

* *Lib. 4. Cap. 16.*
as he is published
by Purchas.

sown. Which passages, especially the former, speak of an Increase that seems so little Credible, that I should on that account forbear to mention it, were it not that in *Europe*, and even in *England*, I my self have reckon'd such a multitude of Grains upon one of the very numerous Ears produc'd by the same single Grain, that I found my self very inclineable to absolve *Acosta*, and continue to look upon him as one of the best Writers of the Natural Historie of *America*.

We now proceed to take notice, that in some Eastern Countries, a sort of Rice (a Grain that makes the chief and most usual food of the Natives over almost all those parts) prospers very well upon Land so drencht with Waters, that Seeds-men, to scatter the Rice, do rather Wade than Walk. But this it self (which, for the main, was confirm'd to me by Eye-witnesses) is lesse strange, and does lesse illustriously confirm what I was proposing, than what the inquisitive Jesuite *Martinus* affirms to be the practice of some (as well great as small) Countries in *China*, where, in divers places that are all the year under water, and would by our *European* Husbandmen be thought capabable of no other use, than that of Ponds or Lakes, the *Chinenses* cast a certain Seed so well appropriated to the place that is to receive it, that though it falls not immediately on the Land but on the Water, (so that one would think they were not about to sow a Field, but bait a Pond for Fishes) yet this Seed, being adapted to the Soile it meets with at the bottom of the water, does so well prosper and shoot up to the top, that in its proper Season the surface of the Water looks as fresh and verdent as a fruitful Meadow, and yeilds as rich a Crop. But for fear of digressing, I shall, *Pyrophilus*, proceed to tell you, that perhaps also Chymistry, especially in conjunction with Hydrostaticks, may prove serviceable to the ingenious Husbandman, by assisting him to discover the kinds and degrees of Saltnesses, that are in several other Bodies that he much
deals

deals with. I remember I have met with things surprizing enough, in examining some sorts of Earths by Distillation, and by several Chymical Instruments of Discovery; but though I have likewise had the Curiosity to distill Dungs and Grain, and Fruits, and some other Subjects, wherewith the Husbandman is conversant, to observe what kinds of Saline and other Liquors, and in what proportion, and of what strength, they could afford me; yet not having any Notes by me of the particular Trials, I shall content my self to have given you this hint of a new sort of Experiments in Husbandry, and shall onely adde, as to Salts, That since the fertilizing power of Dungs seems to reside in the Salino-sulphureous part of them, (and the like I have by Chymical Trials found in Lime;) a practical insight into the differences and differing Operations of Salts (about which I elsewhere entertain you) may probably very much assist the Husbandman to examine the several Dungs, and other Composts, (the knowledg of which is of great moment in his Art,) and to multiply, compound, and apply them skillfully.

And as Chymistrie, that is conversant about Fire; so even Hydrostaticks and Hydraulicks, that teach us to make Engines and Contrivances for the lifting up, and for the conveying of Water, may in divers places be of no small use to the Husbandman. For not to mention what is done in some more known parts of the East, of the like nature with what I am going to mention, *Martinus* informs us, That in one Province of *China* (whose Name I remember not) they are so curious to water their Fields of Rice, that they have upon the River excellent Mills so made, as that great quantities of Water are continually rais'd in Buckets, or other convenient Vessels, fastned to vast Wheels driven by the stream, which watering-Mills (to add that notable Instance upon the by) are not (as our *European* Mills are wont to be)

fixt

fixt to one place, but built upon Vessels, with which they may remove the Mills, how great soever, from place to place, as occasion requires. Nor is this Eastern way of raising Water by Wheels, so as that it may be conveyed by convenient Channels to places many foot higher than the River, or other Receptacle of the Water that is to be distributed, the onely way whereby the Hydraulist and Mechanician may assist the Husbandman, since he may considerably do it by the Art of Libellation, or conducting of Water upon the Ground. For the Improvement that may be made of Land by water, *in Soils fit for that way of Culture*, may be far more considerable than is yet wont to be taken notice of, (as indeed this Husbandry it self is in many Countries both elsewhere, and in *England*, as yet unpractis'd.) I have had some Lands of my own much better'd by being skilfully overflown, so that when I observ'd the difference, the Tenant, though shy of acknowledging the utmost Advantage, confest to me, that he thought it yeilded him double the former Income. And a Gentleman of Quality of my Acquaintance, whose Improvements I went lately to view, shew'd me a Scope of Ground, which at his first coming to that wild place (four or 5 years agoe) was boggish, and which yet he had turn'd into a good dry Soyl, by onely trenching it here and there with shallow Trenches of not a Foot deep, and overflowing it (by the means of those Trenches, and conveniently plac'd Dams) as evenly as he could 5, 6, or 7 times a Year, betwixt the beginning of October, and about the middle of April with the Water of a neighbouring Spring, which was no way enrich'd by Land-floods, arising but in a very barren and uncultivated place, far from the neighbourhood of Grounds capable of enriching it, and yet this Spring drain'd away (if I may so speak) that Ancient Hydropical Distemper of the Land, and turn'd it, as I found by Trial, into a good compact Soile, on which store of
Mowers

Mowers were (when I saw it) imploy'd in making of Hay, which this Medow yeilded plentifully enough to be worth 20 times its former value. Nor is this the single Considerable Instance we have met with, of the Improvement that may be made of divers kinds of Land, onely by skilfully overflowing them with common waters:

But, *Pyroph.* I may hereafter have so many occasions to mention particulars relating to Agriculture, that I should presently dismiss them in this Essay, were it not that I am by my having nam'd Husbandry to you, put in mind to imploy it as an Instance to confirm this Observation, That the more comprehensive a Trade is, the more likely it is that it will be capable of being meliorated by Natural Philosophie. For such Trades, as are of great extent, are oblig'd to deal with a considerable number of Natures Productions, and to make use of divers of her Operations, and consequently must comprehend the more particulars, wherein the Manufacture or Profession may be reform'd, and otherwise advantag'd by a knowing and dexterous Naturalist. Thus the Husbandman's Corn makes it fit for him to have a competent skill in the whole Art of Tillage, the keeping of Cattle great and small, the ordering of Dairies, of Wood, of Flax and Hemp, of Hops, of the Kitchen-garden, of an Orchard, of Bees, &c. besides that the particular Productions of some of these, as Honey, Cydar, &c. require some skill, and are capable of much Improvement; so that among so great a variety of things wherewith the Husbandman has to deal, it can scarce be otherwise than that there will be several things, wherein the Naturalist's higher and more reaching Knowledge and Experience will be serviceable to him. And whereas in the Preservation both of Cattle from Diseases, and of the Fruits of the Earth from Putrefaction, lieth one of the most beneficial and difficult parts of the Husbandman's skill, he may therein be much assisted by an expert
Nac

Naturalist, who not onely, by being able to accelerate Putrefaction in divers Bodies, may teach the Husbandman to furnish himself with great variety of Composts and Manures, to relieve and enrich his Ground with what ever peculiar sort of Salt he observes to be deficient; but also may teach him how to preserve many of his Seeds, and Flowers, and Fruits, beyond their wonted duration: as I know some persons, to whom I recommended Methods of this kind, that use to preserve Quinces, for Instance, a great part of the Year, by a strong Liquor (or Pickle) made of nothing but Water, and what (for the most part refuse stuff) may be easily obtain'd from the Quinces themselves. This way presented us Fruit at almost the Years end; and a while since I could have shewn You (and, for ought I know, can do so yet) Cherries well shap'd, and succulent enough, of above a Year old, preserv'd without Salt or Sugar, by being kept in a spirit of Wine fitted for that use, and fully impregnated before their immersion with the Tincture of the skins of other Cherries of the same kind. The vast Benefit that the *Hollanders* derive from the best way of Salting or Pickling of Herrings, and the advantageous use that is made by others of so powdering Beef, and ordering other Flesh, that will last good to the *Indies*, and is sometimes brought uncorrupted into these parts again, may perswade us of the Benefit that may accrue to the Husbandman, by the Discovery of the wayes of keeping the Productions of the Earth from Corruption; especially if his skill be extended to weak Wines, Cidar, Perry, and other Liquors, which are wont to be made in great Quantities, and yet apt to decay at home, and unfit to be transported far abroad. And the use of Sugar to strengthen vinous Liquors, and make them durable, and, without the help of Salt or any sharp thing, to preserve great variety of Fruits, and of the Juices of Herbs, may encourage us to think, that there may be very differing wayes (and

(and some of them seemingly oppositely) to make many things outlast their Natural periods of Duration.

But my Trials and Observations (whether about the conserving of Fruits, Flowers, and Flesh, or of other things of this sort) belonging more properly to another Discourse (*of the Preservation of Bodies*) I shall now mention no more of them, but passe on to tell you, that very much prejudice, which often happens to the poor Husbandman (and sometimes even to his utter ruine) by those either stubborn or contagious Diseases, (such as the Rot in Sheep, and the Glaunders in Horses,) that make havock of his Cattel, may in great measure be prevented by the instructions of a knowing Naturalist, especially if he be an expert Physitian too. For, as many Diseases, so many Cures are analogous in Men and Beasts, and the Remedies prove frequently more successful in these than in them, as well for divers other Reasons, as because the Bodies of many Brutes are more able to bear the Operation of strong Remedies; and yet the unaccustomedness of almost all of them to Physick, makes them more relievable than Men by any (not improper) Remedies. I will not now relate that I have in some Countries found Medicines that have been usefully tried against Diseases in Men, cry'd up for their efficacy against their analogous ones in Horses; nor with what difference in the Dose these may be purg'd by several of the same Catharticks, especially Aloes, that are employ'd for the Purgation of humane Bodies. I shall rather inform you, that *as* in these, Salt is (you know) reputed a great resister of Corruption, and an Enemy to Worms, (with a sort of which the Livers and neighbouring Vessels of Sheep have been observ'd to be infested;) *so* by the bare use of (*Spanish*) Salt, of which each Sheep, being first made to bleed a little under the Eye, was made to take down a small handfull two or three times (with some dayes of Interval,) without being suffer'd for

some hours to drink any thing after it: by this Remedy, I say, given at the time of the Year when there is danger, that the Sheep will begin to be botcht, many Flocks have for divers Years been preserv'd by a rich intelligent Gentleman of my Acquaintance, that is a great Sheep-master, and has thereby (and that also lately) preserv'd his Flocks in a moist Countrey, when most of his Neighbours lost theirs. I might here mention to you, *Pyr.* the Virtues of crude Antimony, to cure the foulness of Blood, and even the Leprosy in Swine; of Quick-silver, to cure the Worms in Horses; of *Palmaris* his famous Remedy, which he solemnly affirms to be a constant one against the Bitings of a mad Dog in Cattle, and of a more parable one for Men also, whose success I almost admir'd in a neer Relation of Yours and Mine; of the use of the Antimonial Cup for several Sickneses in Horses and Sheep, which (if I mis-remember not) was successfully tried by one to whom I recommended it; and of another Antimonial Medicine, which (though much commended to me by a *Virtuoso* that took it himself) a Gentleman of my Acquaintance resident in the Countrey, who prepares it, assures me, that he uses it with strange success to fatten his Horses, (made lean by occasion of Sicknesse,) with whom yet it works not, either as an Emetick, or a Purge. And I could here present you divers other Receipts much priz'd for their having (as well as the newly mention'd Remedies) frequently been found effectual against the same Diseases both in Humane Bodies and in Brutes, if I did not think it lesse proper to make in this place a *Veterinarian* Excursion, than to tell You, that, if You have any Curiosity for them, You may command them.

I might adde, if I had leisure, some Reasons why I despair not that in time the Husbandman may, by the Assistance of the Naturalist, be able to advance his Profession by a Therapeutical part, which may extend not onely to the Animal
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productions of the Ground, and to the Vegetable ones; but (in a large acception of the Term) to the Distempers of the Ground it self. For if the Causes of the Barrenness of Soils in general, and of their Indisposition to cherish particular Plants or Animals, were by the Philosopher's sagacity discover'd, I see not why many of those Defects may not be remov'd by rational Applications, and proper wayes of cure; as well as wee see Inconveniences remedied in many other inanimate Bodies, without excepting the close and stubborn Metalline ones themselves.

And perhaps also, that by a way of management suggested by the knowledg of Causes, the barrenness of a Soil may be cured, or its Fertility much promoted by methods, that do nothing neer so much require Cost as Skill. Some ingenious Husbandmen have of late proclaim'd themselves much satisfied with a way of correcting two of the barrenst sorts of Land, not by rich Manures or other costly cultures, but by skilfully mixing the Sand and Clay themselves in a due proportion, according to the Use the Husbandman designs to make of it. And whereas one of the best modern Writers of Agriculture reports, as he may, for a strange thing, that he had seen seven or eight and thirty Ears of Barley that sprung from one Grain; I remember, that an Ingenious Gentleman, to satisfy some Curious persons what might be done in that kind, sow'd Corn upon a piece of Land, very neer the place of my abode, which prosper'd so strangely, that one Root that I took particular notice of, though perhaps not the fruitfullest in the field, produc'd sixty and odde Ears of Corn, and yet, which was the strangest, this wonderful Increase depended upon a Philosophical Observation; nothing extraordinary having been done, either to the Land, or so much as to the Seed; as I had opportunity to know, both by the informations of observing men, and by the confession of the Gentleman himself, who was

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pleas'd

pleas'd to make choice of me to intrust his Secret with, that in case he dyed before me, the publick might not loose it. Upon which account he also confided to me another Specimen of his skill. He once presented your Excellent Mother a company of several sorts of choice Apples, among which there was one sort excellently tasted, but very small; the following Year he presented her another Basket of the like Fruit, but finding no small ones among them, she took occasion to ask him, What was become of the Tree that produc'd those delicious little Apples, that made part of his former Present? to which he replied, that he had brought several of its productions among the other Fruits she was looking on; and thereupon shew'd her some that came from the same Tree, and appear'd by the peculiar Relish to be of the same sort, though exceedingly differing in Bulk, that neither your Mother, nor I, had any suspicion that the same Tree bore them. Upon which occasion he readily gratified my Curiosity by acquainting me with his way, which depended almost onely upon a Physical Observation; all that he added being not any rich Compost, but some despis'd Leaves of a very cheap and common Vegetable. But Husbandry is too large a subject for me to prosecute in this place, and therefore I shall here dismiss it.

THE III. SECTION.

THE next thing I shall observe to You, *Pyroph.* is, that it is not onely to the Trades that minister to the necessities of Mankind, but to those also that serve for Man's accommodation or delight, that Experimental Philosophie may bring Improvements; for these Arts also do for the most part consist in the knowledg and application of some of Natures Productions and courses, whose being referr'd to the accommodation or delight of Men, rather than to any other

other purpose, does produce nothing that is truly Physical in the things so referr'd, which thereby acquire onely such a kind of respect to Man, as that which the Metaphysicians call an *Extrinfecal Denomination*; and we see that the same things, without varying their Nature, are serviceable to men in very differing capacities: as Wine serves one that is dry to quench his Thirst, serves a fainting person to revive his Spirits, and the Drunkard to inebriate him; the same spirit of Wine that serves the Physician to make Tinctures and Extracts for the recovery of Health, may serve the Ladies to dissolve Benjamin into a tincted Liquor, that diluted with fair Water, may be us'd as a Cosmetick, which I have received many thanks for; and the same Spirit skilfully employed upon Ingredients to be nam'd to you ere long, is of excellent use for making of divers fine Varnishes made with rectify'd spirit of Wine; nay the newly mention'd Solution of Benjamin may it self be applied to all those differing uses; for of it self it is a pretty and odoriferous Varnish, and I have us'd it (though not often, for want of opportunity) with very good success against a sort of Tetters, which I caus'd frequently to be bath'd with it. What happy applications Knowledge and Skill may make even of unpromising things, to the furnishing men with Delights, is me thinks very evident in Musical Instruments, (as Lutes, Viols, &c.) For who would think (if Experience did not assure us of it) that with a few pieces of Wood join'd together, and the Guts of Cats or Lambs wreath'd or twisted into Strings, the skilful Musitian, by the help of Mathematicks and Exercise, should be able to charm the Ear with the greatest, as well as most innocent, Delights, the Sense belonging to the Organ is capable of, and which sometimes does not onely please, but ravish the transported Hearers. But though, *Pyrophilus*, as I was lately saying, Physicks may not onely be very improving to those Arts and Professions that serve to provide man with

with the Necessaries or Accommodations of Life, but also to those that serve chiefly to furnish him with Pleasures and Delights; as might be instanc'd in Experiments of Colouring, Perfuming, making Sweet-meats of all Sorts, embellishing the Face with Cosmeticks, and divers others of the like voluptuous nature: and though I may elsewhere have occasion, when I come to treat of Colours, Odors, Tastes, and other Qualities, to acquaint you with some Receipts and Experiments of this kind, yet now I do not onely want leisure to mention them, but am desirous that Natural Philosophy should engage You to Court her, rather by Her gratifying and enamouring your Reason, than by Her bribing and inveigling your Senses.

THE IV. SECTION.

THough what has been represented about the Usefulness of Experimental Philosophy to Trades, does chiefly belong to those, wherein Natures Productions are employed to Humane Uses, by those Operations wherein Nature her Self, rather than the Artificer, seems to have the chief hand, as the Trades of Brewing, Baking, Gardening, Tanning, &c. yet I would not exclude those very Trades wherein the Artificer seems to be the main Agent, and in whose ultimate Productions the chief thing, that is wont to be consider'd, is the adventitious Shape or Form, which the Artificer, as an intelligent and voluntary Agent, does, by the help of his Tools, give the Matter he works on, as in the Trades of the Smith, the Mason, the Cutler (when distinct from that of the Sword-maker,) the Watch-maker, and other Handicrafts. For though these consist rather in the Manual dexterity of Men, than the skilful ordering of the Productions of Nature, by their material Operations upon one another, yet to many, if not all, even of these, the Naturalist may some way or other be a Benefactor.

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For there are divers of these Manual Trades, that, especially as they are exercis'd in Cities and greater Towns, consist of several parts, and have need of several other Trades to prepare Materials for them, and dispose them to receive the last Form which the Artificer is to give them, to fit them for Sale. And we may in many cases observe, that though this Artificer, that gives the Matter this last Form, does it chiefly with his Hands and his Tools; yet those other Tradesmen, to whom he is beholding for his Materials, do some or other of them, to prepare and qualify them for his Use, need some Observations of the conditions of the Body they deal with, or must employ some Physical Operations, wherein they may be much assisted by the knowing Naturalist, who may also teach the manual Operator himself how to make choice of his Materials, and examine the goodnesse of those that subordinate Workmen shall bring him. Thus though Stone-cutting be a Trade, that seems to consist almost wholly in giving, with proper Tools, to Marble, Free-stone, and other Materials, the Shape which the Artificer designs, yet, if I had leisure, I could easily shew You, that even in this Trade there are many particulars, wherein Experimental Philosophie might be helpful to the Artificer. For wayes, hitherto unus'd, may be found out (as I have partly tried) to examine the nature and goodnesse of the Marble, Alabaster, and other stones which the Mechanicks deal with. A competent knowledge of the Sap that is to be found in Stones employ'd for Building, is of so much importance, that the experienc'd Master Workmen have confest to me, That the same sort of Stone, and taken out of the same Quarry, if digg'd at one Season, will moulder away in a very few Winters; whereas digg'd at another Season, it will brave the Weather for very many Years, not to say, Ages: (but of my Observations of this kind more elsewhere.) The Cements also, and Stoppings (as

(as they call them) which are of good use in this Trade, may be easily better'd by the Naturalist that is vers'd in such Mixtures. And I remember I had occasion to teach a fine Cement for the rejoyning of the broken Limbs of Statues to their Bodies, to an inquisitive Artificer, who by such like helps did in other cases so well counterfeit Marble with a Cement, that even where there was occasion to fill up great Cavities with it, the work would passe for entire; the Ad-ditaments being not distinguish'd from the Natural Marble. Want of Curiosity also keeps our Stone-cutters here in *England* unacquainted with the ways of working upon Porphyry, which they will not undertake either to polish or to cut. Nor is *England* the onely Countrey where the Art of working upon Porphyry (which appears to have been in great use amongst the *Romans*) is unknown, though at *Rome* there are some few that do with great Gain exercise it. And though I know not precisely what tis they imploy, yet I presume it may be Powder of Emery: for with That and Water, and Steel-saws, I have here in *England* caused a Porphyre stone to be cut. And the mention of Porphyre puts me in mind of telling You, that by an Art I have, white Marble may be so stain'd, and that durably, with Spots great or small, and red or brown, as it pleaserh the Artificer, as I may hereafter have occasion more fully to relate. Twould be too long to discourse to you here of Artificial Marble, and divers other things that Stone-cutters affirm to belong to their Trade, wherein you will scarce doubt, but that it may be capable of improvement. Wherefore I shall onely adde, that whereas this Profession does much require very good Steel-tools, and they must have these from Smiths, and others that deal in Iron, if these Mens Trade were better'd by the Naturalist, they might be able to afford the Stone-cutter the better temper'd Tools: and that even the Smiths Craft, though it seems to be meerly a Manual Art, is yet

capable of much melioration by the knowledge of Nature, were not difficult to manifest, if twere proper here to insist on the Proofs of it; yet thus much I shall here take notice of to confirm this IV. Observation, That not onely the Philosopher may, as a Mineralist and a Mechanician, improve the wayes of making Iron and Steel, before they come to the Smiths hand, but likewise may devise better Expedients, than are among us in use, for the ordering of Iron and Steel, when it comes to be formed into Weapons and Tools. The Sword-blades, and other Arms, that are made at *Damasco*, are very famous every where, and (as far as some Trials have inform'd us) justly for their excellency in cutting even Iron. And yet it seems to be onely the skill of the Artificers in ordering it, that gives the Swords and other Instruments made at *Damasco*, so great a preheminance above others. For though the goodnesse of them have been presum'd to proceed from that of the Iron-mines, and Steel, peculiar to the Region of that City; yet the judicious *Bellonius*, having made particular Enquiry at his being there, informs us otherwise, and tels us, that Iron and Steel, being brought thither from other parts, (the Countrey having no Mines of it) receives there from the skill of the Workmen its Temper and Perfection. And I see not why I may not reasonably suppose, that in the tempering of Steel, tis not onely the goodnesse of the Metal, and the determinate degree of Heat, though these be the onely things Artificers are wont to look after, that give the best Temper; but that much may depend upon the Nature of the Liquors, or other Bodies, wherein the hot Steel is plung'd, and upon other wayes of ordering it, if those be skillfully chosen and employed. I have had a Graver so well temper'd, (but by whom I know not) that all the known wayes us'd by me and others, (who wondered, as well as I, at the unsuccessfullnesse of our Endeavours,) could not deprive it of its Temper, as they would

P. Bellonius observat. lib. 2. cap. 93.

have done any Gravers that we make here ; and twas afterwards affirm'd to me, that it was made of Steel temper'd at *Damasco*.

I may elsewhere tell You, *Pyrophilus*, both of a way I have tried, of hardening Gravers, without quenching them in any Liquor or Tallow, or any other Unctuous Body; and that having perswaded an Ingenious Artificer to try an unpractic'd way of tempering Gravers, he soon after brought me one to see the goodnesse of it, which, by being plung'd in a certain cheap Mixture, (wherewith I may hereafter acquaint You) had been harden'd and temper'd at once: which though most Artificers would think scarce possible, yet upon the Authority of Trial, I shall venture to deliver what some may think as strange, namely, That though Ignition and Extinction in cold Water, be the common and known way to harden Steel (Gravers,) yet by that way, onely observing precisely a Nick of Time, Steel may be made strangely Soft. But of this more elsewhere. I shall now adde, That having enquir'd of one of the Curiousst, and most observing Makers of Steel-Tools, whether he did not find a difference in the imploying of Pump-water, or River-water in giving them their Temper, he satisfied me that he did so; and observ'd the former to be fitter for some sorts of Tools, and the later for others. There may be divers other Particulars, wherein Iron and Steel may be improv'd by the Naturalist. The first may be this: that the Metal be render'd so soft, as to be, by the help of strong Moulds, put into Shapes. This an Eminent and credible Artificer assur'd me, he had often seen his Master do to Iron, with considerable profit. Or else it may be made fusible like an other Metal, as I remember I have (sometimes with a certain Flux-powder, which I compos'd, if I much forget not, of Tartar, Sulphur, and Arsenick) made it run, even with a Charcoal fire, into a Masse exceeding hard, and very polishable.

able. A third way may be this: That it be so ordered, as to be preserv'd very long from Rust, which an Ancient *Virtuoso*, who had purchas'd the Secret of a rare Artist, for a great Prince, and us'd to shew his Friends Steel so prepar'd, assur'd me was done chiefly by tempering it in Water well impregnated with the Bark of a certain Tree. In a word, there may be divers other wayes whereby Iron or Steel themselves, or their Trades that imploy them, may be meliorated; and to adde, that on this occasion there are many and very differing accounts, upon which a Trade or Profession may be benefitted by the Experimental Philosopher: for he may *either* find out variety of Materials wherewith to perform the things desired by the Tradesman, *or* he may render those Materials that are already in use, better condition'd; *or* he may discover and reform the unheeded Errors and Mistakes to be met with in the Trade; *or* he may devise more easie and compendious wayes of producing the Effect that is required; *or* he may improve some of the auxiliary Trades, of which the Trade spoken of has need or use; *or* he may instruct the Artificer to choose, and examine, and preserve his Materials and Tools, better than is usual, *or* can make the ultimate Productions of his Trade sooner, or cheaper, or easier, or better condition'd, or applicable to more Uses, or more durable, than they are commonly made. Nor are these all the particulars that might here be enumerated to the same purpose, if this IVth Consideration had not detain'd us too long already.

THE V. SECTION.

THe Naturalist may increase the Power and Goods of Mankind upon the account of Trades, not onely by meliorating those that are already found out, but by introducing new ones, partly such as are in an absolute sense new-

ly invented, and partly such as are *unknown* in those places, into which he brings them into request. For twere injurious both to Nature and to Man, to imagine that the Riches of the one, and the Industry of the other are so exhausted, but that they may be brought to afford new kinds of Employments to the hands of Tradesmen, if Philosophical Heads were studiously employed to make Discoveries of them. And here I consider, that in many cases a Trade differs from an Experiment, not so much in the Nature of the thing, as in its having had the luck to be applied to Humane Uses, or by a Company of Artificers made their Business, in order to their Profit; which are things Extrinsic, and Accidental to the Experiment it self. To illustrate this by an Example, the fishing Explosion made by a mixture of Nitre, Brimstone, and Charcoal, whilst it past not further than the Laboratory of the Monk, to whom the Invention is imputed, was but an Experiment; but when once the great (though unhappy) Use that might be made of it, was taken notice of, and Mechanical people resolv'd to make it their Profession and business to make Improvements and Applications of it; this single Experiment gave Birth to more than one Trade: As namely, those of Powder-makers, Founders of Ordnance, Gunners (both for Artillery and Mortar-pieces,) Gun-smiths; under which name are compriz'd several sorts of Artificers, as the makers of Muskets, small Pistols, common Barrels, screw'd Barrels, and other varieties not here to be insisted on.

The Discovery of the Magnetical Needles property to respect the Poles, has given occasion to the Art of making Sea-Compasses, as they call them, which in *London* is grown to be a particular and distinct Trade. And divers other Examples may be given to the same purpose, especially where Mechanical Tools and Contrivances cooperate with the Discovery of Natures Production. So that oftentimes a

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very few Mathematical Speculations, or as few Physical Observations, being promoted by the contrivance of Instruments and the practice of Handicrafts men, are turn'd into Trades; as we see that a few Dioptrical Theories lighting into Mechanical hands, have introduc'd into the World the Manufactures of Spectacle-makers, and of the makers of those excellent Engines, Telescopes and Microscopes.

The observing, that though Quick-silver will Amalgame with Gold (and thereby seem to be destroyed, (which made *Pliny* think it an Enemy to Metals,) yet it may be separated from the Gold again without diminution of that noble Metal) has brought forth the Trade of Guilders, whose Art consists chiefly in mixing, by the help of a competent heat, good Gold with five, six, or seven times its weight of Quick-silver, till the mixture come of such a consistence that they may spread it as they please upon the Silver or Copper to be gilt. For having by this means overlaid it evenly with Gold, they can easily with fire force away the Mercury; and with a liquor impregnated with Nitre, Verdigrease, Sal Armoniack, and other Saline Bodies, which they call a Colourish, restore its lustre to the remaining Gold, which they after make bright by polishing.

The almost obvious and trivial Observation made by some sagacious person (whoever it was) that a Spring was a Physical continual and durable Power or Force, and the Corollarie he thence deduc'd, *that this Force, skilfully applied, might be equivalent to the Weights that were thought necessary to move the wheels of Clocks*: these Reflections, I say, join'd with a Mechanical Contrivance, produc'd those useful little Engines, Watches, that now afford a plentiful Livelihood to so many dexterous Artificers; which though Custome has made familiar to us, yet were unknown to the Ancients, and highly priz'd and admir'd in *China* it self, when first (in the last Century) brought thither. The Discovery of the
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virtue of *Aqua fortis* to dissolve Silver and Copper without working upon Gold, added to the Observation, That Lead melted with either of the two noble Metals, and then forc'd from them by Fire, will carry away with it any of the baser Metals that may have been mixt with them; (these two particulars, I say) have begot in later Ages the Art of the Refiners we now have.

Mens having observ'd the Operations of some Lixiviums, Claies, and a few other familiar things upon the Juice of the Sugar-Cane, has not onely occasion'd the adding of the Culture of those Reeds to the other parts of Husbandry left us by the Ancients; but has produc'd the several Trades of Sugar-boilers, or makers of Sugar, Refiners of Sugar, and Confectioners: not to mention the great addition the concreted Juice of the Sugar-Cane brings to the Apothecaries Profession, upon the score of Syrups, Conserves, Electuaries, and other Saccharine Medicines. Nay, a very slight manual Contrivance or Operation, if it light fortunately, may supply men with a Trade, as in the Art of Printing. To which I shall onely adde, that in *China*, and some other Eastern parts, the lucky Trial that some made to bore very small Holes through *Porcellane* or *China* Cups, and employ very slender Wire in stead of Thread or Silk, has given being to the vulgar Trade of those people that go up and down in those Countries, as Tinkers do with us, getting their Livelihood by sewing together the pieces of crackt or broken *Porcellane* Vessels: as I have been inform'd by more than one credible Person that liv'd in the East, and had Experience of the use of Cups so mended, though fill'd with Liquors as hot, as they are wont in the East to drink their Cofée and Tée.

The mention freshly made of *China*, brings into my mind, That whereas the knowledg of some Gums and Liquors in that Countrey, afforded them those useful, as well as most beautiful,

beautiful, Varnishes, which we call by the name of the Kingdom that supplies us with them; and which do both there, & in *Japan*, employ multitudes of Tradesmen, I am credibly inform'd, that the Art of making the like Varnish'd Wares, is now begun to be a Trade at *Paris*, and I doubt not but it will ere long be so in *London* too. For though some Accounts, that were given me by *Virtuosi* of that Varnish, were such, that the Trials of them did very ill answer Expectation; yet having read in *Linschoten's* Voiages, that in *China* and *Japan* they make this excellent Varnish of Gum *Lacca*, I found by some Trials, that I was able to imitate one of the best sorts of it, by dissolving the Gum in high rectified Spirit of Wine, and then giving it a Colour, and laying it on in such a manner as I may have ere long a fitter occasion to inform You.

See the App. to the V. Essay.

And without much impropriety, I might alleadg the Art of cultivating and gathering Sugar-Canes, and of ordering their Juice, as a recent Instance of the transplanting of Arts and Manufactures. For, as I am inform'd by very credible Relations, there are not yet very many years elapsed, since, in our memory, a Forreigner accidentally bringing some Sugar-Canes, as Rarities, from *Brasil* into *Europe*, and happening to touch at the *Barbadoes*, an English Planter that was Curious, obtain'd from him a few of them, together with some Hints of the way of cultivating and using them. Which, by the Curiosity and Industry of the English Colony there, were in a short time so well improv'd, that that small Island became, and is still, the chief Storehouse that furnishes, not onely *England*, but *Europe* with Sugars. And this Instance I the rather mention, because it is also a very notable one, to shew, how many Hands, the Introduction of one Physico-Mechanical Art may set on work; since I have had particular opportunity to learn by Enquiry, that the *Negroes*, or, as they call them, *Blacks*, living

ing as Slaves upon that spot of Ground, and imploy'd almost totally about the planting of Sugar-Canes and making of Sugar, amount at least to between five and twenty and thirty thousand persons. And that you may see how Lucriferous in that place this so recent Art of making Sugar is, not onely to private men, but to the publick; I shall adde, that by divers intelligent and sober persons interested in the *Barbadoes* (and partly by other wayes) I have been inform'd, That there is, one Year with another, from that little Island, which is reckon'd to be short of thirty Miles in length, (and so I found it, by measuring it on one of the fairest and recentest Maps,) shipt off for *England* (especially,) ten thousand Tun of Sugar, each Tun being estimated at two thousand Pound weight, which amounts to twenty Millions of Pounds of that Commodity; which though it may seem scarce credible, yet one of the Antient Magistrates of that Island lately assur'd me, that some Years it affords a much greater quantity.

I shall not fortifie what I have hitherto discours'd with Particulars, that will elsewhere more properly fall in; it being sufficient for my present purpose, that the Instances already mention'd may render it probable, *That the Experimental Philosopher may not onely Improve Trades, but Multiply them*, till I have occasion in the Last Essay of this Book, to make it out more fully. Nor do I despair, that among other wayes whereby Trades will be increas'd, one may be the retrieving some of those that were anciently practic'd, and since lost, of which we have a Catalogue in the Learned *Pancirollus*. For as tis the skilful Diver's work, not onely to gather Pearls and Coral that grew at the bottom of the Sea, and still lay conceal'd there; but also to recover shipwreck'd Goods, that lay buried in the Seas that swallowed them up: so tis the work of the Experimental Philosopher, not onely to dive into the deep Recesses of Nature, and
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thence fetch up her hidden Riches; but to recover to the use of Man those lost Inventions, that have been swallowed up by the Injuries of Time, and lain buried in Oblivion. This I do not say altogether groundlesly, though for some Reasons I here decline mentioning the things that induc'd me to say it.

THE VI. SECTION.

TO what has been hitherto said, I shall venture to adde, not onely that the sagacious Philosopher may better most of the Trades that are already in use, and adde to the number of Mechanical Employments; but that I am apt to think it might without much *Hyperbole* be affirm'd, that there is not any one Profession or Condition of Men (perhaps scarce any single Person of Mankind) that may not be some way or other advantag'd or accommodated, if all the Truths discoverable by Natural Philosophie, and the Applications that might be made of them, were known to the Persons concern'd in them. So that besides those Discoveries that are compil'd or form'd into Trades, there are, and may be, found, a multitude of loose particulars, whereby the Naturalist may much gratifie and assist men, according to the exigency of particular occasions. The nature of the thing will scarce permit me to illustrate so unlikely an Assertion, without employing instances in themselves trifling, if not despicable; of which I will therefore give you but a few, because if they were not pertinent to my present purpose, they would be fitter to divert, than inform, You.

I had, not long since, the honour to be known to a very great Court-Lady, who was much troubled, that having frequent occasion to write Letters, she could scarce handle a Pen without blacking her Fingers with Ink; I smilingly undertook to make her write without Ink, which I my self was formerly wont to doe, by first preparing my Paper with

a Powder made of Copperas, slightly calcin'd upon a Fire-shovel till it grow friable, and Galls, and Gum-Arabick finely pulveriz'd, and exquisitely incorporated with the Vitriol in a certain proportion; which though a few Trials will better teach than Rules, (because according to the Goodness and Calcination of the Vitriol, the proportion of the other Ingredients must sometimes be varied,) yet to assist you in your first Guessees, I shall tell You, that (for the most part) I us'd my self 3 parts of calcin'd Vitriol, 2 parts of Galls, and 1 part of Gum-Arabick, and mixt them not before I was ready to imploy them, for this Powder being with a Hares foot, or any other convenient thing, carefully rubb'd into the Paper, and the looser Dust struck off, doth, without discolouring it, so fill its Pores with an Inky mixture, that as soon as it is written upon with a clean Pen, dip't in water, Beer, or such other Liquors, the Aqueous part of the Liquor dissolving the vitriolate Salt, and the adhering particles of the Galls, makes a legible Blacknesse immediately discover it self on the Paper. This mention of Writing brings into my mind, that several times having had occasion to make a Word or two, that was but lately written, look as if it had been written long before, I perform'd it, by lightly moistening the Words I would have to look old, with Oyl of Tartar *per deliquium* allay'd with more or lesse fair Water, according as I desir'd the Ink should appear lesse or more decayed: which Experiments may be often useful in Manuscripts, to keep the recent interlineations, or other Additions, from betraying themselves by their freshness not to have been written at the same time with the rest of the Manuscript.

And the Design I had in making use of the lately mentioned Powder of Galls and Copperas, puts me in mind of another way of writing without Ink, (and too without danger of blacking ones Fingers or Linen,) which I remember

I have practis'd sometimes with one Powder, and sometimes with another. For considering that common Silver being rubb'd upon Bodies, whose Surfaces are a little rough, and even upon colour'd Cloath the Metal would leave a Blacknesse on it, twas easie to conclude, That if the surface of the white Paper were asperated by a multitude of irregular Grains of a Powder as white as it, would retain a Blacknesse wherever a blunt Silver Bodkin should be drawn over the grating Particles: and accordingly I found, that either exquisitely calcin'd Harts.horn, or clean Tobacco-pipes, or (which is better than that) Mutton-bones (taken between the Knuckles, and) burnt to a perfect Whitenesse, being finely powder'd and sear'd, and well rubb'd upon Paper, would make it fit to be written upon with the point of a Silver Table-book pin, or Bodkin of Silver (which Metal is not absolutely necessary in this case,) as well as that which is called Mathematical Paper, (if the being prepar'd with one, or other of these Powders do not make it the same.)

And now I am upon the mention of such Preparations of Paper, I remember, that I was once in a place where I could get no white Leaves, to supply a fine Table-book that I had much use for; nor could I hear of any Tradesman in the whole Countrey, that knew the way of making so much as ordinary Table-books: wherefore I be-thought my self of trying to make something by way of *succedaneum*, which succeeded at the first attempt. And though there may be better wayes to make white Table-books, yet perhaps you will find none more simple and easie, the two onely Ingredients we had in it, being to be had at every Apothecaries Shop. I onely take Ceruss, rubb'd to very fine Powder, (which is done in a trice) and temper it up with fair Water glutted with clear Gum-Arabick. With this mixture (being brought to the consistence of a somewhat thick Salve) I rub over the Paper I prepare, putting on more or

lesse according as I would have it last, and having suffer'd it to dry (which it will quickly do) it may, if there be occasion; be presently us'd with the point of a Silver-pin, which will make the Letters appear very conspicuous upon a Mixture, that does not at all impair the Whitenesse of the Paper; and what was thus written I could, with Spittle or Water, blot out three or four times successively without spoiling the Paper. Which questionlesse had been much better prepared, if divers Couches of the mixture had been laid on and suffered each to dry, and if afterwards the Paper had been smoothed by being scrap'd with a Knife, and polish'd.

A very ingenious Artificer, who had contriv'd an Instrument useful to others, and profitable to himself, whereof an absolutely necessary part was a Glass fill'd with fair Water, and exactly stop'd, complain'd to me, that though his Instrument did exceeding well in all but Frosty weather, yet then it was apt to be spoil'd by the freezing of the included Liquor, which too often broke the Glass. Whereupon I taught him to remedy it, by substituting in stead of Water good spirit of Wine, which has not in our Climate been observ'd to freeze; or rather (because in his bigger Glasses that Liquor would be chargeable) either Sea-water strengthned with a little Salt, or else common Spring-water with a twentieth, or at most a tenth part of Salt dissolv'd in it. For though this Brine look (if well made) as clear as common Water, yet I have not observ'd, that the sharpest of our English Winters would make it freeze.

To a Person of Quality, that was very Curious of the way of writing secretly, I undertook to teach an easie way (which after I knew it, I found also in an old printed Book) of sending a written Message, without putting it into the power of the Bearer to betray it; which I could easily have perform'd my self, if the message were to be deliver'd in a short time, and not too far off, by writing on his Back, or other conve-

nient

nient part of his Body, with a clean Pen dipt in my own Urine, (there being some Urines with which I have found, to my wonder, that the Experiment would not succeed.) For if he that receives the Message rubs but a little of the black substance remaining of Paper after it is burnt, those Sable parts adhering to those other of the Liquor, that lurk yet in the pores of the Skin (whence if the Messenger went fast, and very far, the Sweat would probably dislodge them) do denigrate all that was written, and make it legible enough, sometimes as I have tried after many hours.

I remember too, that intending one Summer to make some abode at a house I had in the Countrey, I sent for from London, among other things, a quantity of Damask Table-Linnen, with which he that sent it me, inconsiderately packt up a great pot of a certain Confection, which for some purposes I had caus'd to be made of the Pulp of Sloes, which, by agitation of the Horse it was carried on, being brought to ferment, and run out of the broken Pot, stain'd all the new Damask from the top to the bottom. At which an old Domestick of mine (whom you remember very well) seeming much troubled because he had sent for it, to convince him that Experimental Philosophy was not altogether uselesse, I kept the stain'd Linnen, for some convenient hours, in new Milk, and afterwards causing it to be thoroughly and diligently wash'd in the like Liquor, the Damask came forth unstain'd, and almost as white as It. What Urine, if duely (and long enough) imployed, may do to take Stains (even of Ink) out of Linnen, is but to be hinted in this place; where I might adde, that with *strong* spirit of Salt, where-with I moisten'd, as often as was needful, the spotted places (first wetted with fair Water,) I have out of new Linnen taken spots of Ink (especially fresh ones) of very differing sizes, without leaving (after the Linnen was well washt out in fair Water) any of those yellow Stains which many call *Iron-Moles*.
Some

Some Ingenious Persons, that deal much in Lixiviums and Brines, complaining the other day, that besides that they could not sometimes easily come at an Egg, to try, by its sinking or floating, the strength of the Saline Liquors they would examine, there needed a good quantity of the Liquor to make such a Trial in; I allow'd their complaint to be just, and the rather, because I observe, for nicer Estimates of the strength of Liquors, the Trial by Eggs is uncertain enough, in regard that even the same Egg will, as I have found, by being kept grow lighter, whence stale Eggs have usually a great Cavity (that seems fill'd onely with Air) at the bigger end: and I told them, to omit the more Artificial, but more difficult, wayes of examining such Liquors, I sometimes us'd a way, whereby I could try the strength of the Lixiviums made with Chymical Salts, though I had not above a Thimbleful of the Liquor, and this with a Body that will not easily wast like an Egg, (and therefore may be kept.) For I substituted, in stead of the Egg, a small piece of Amber, about the bignesse of a Pea, which in a very strong Solution of Lixivate Salt, will, as I let them see, swim on the top, but sink in a weak one. And as you may take a piece of Amber lesse or bigger than a Pea, as best fits your occasions, and need not be at all scrupulous about the figure, (provided the Amber be once well duckt in the Liquor,) so it is some convenience that two pieces of Amber, whereof the one is far more reddish, and the other paler, will be, as far as I have tryed, of somewhat differing Specifick Gravities, so that the one will flote in some Liquors, where, in the other will sink.

I remember I was once in a Countrey, where I had a great mind to try some things with Dantzick Vitriol, or some other blew Copperas, but by reason of the Wars could not possibly procure any, though there were in that Countrey a place, where Green-Vitriol was made by the help of Iron;
wherefore

wherefore getting some of that Liquor which the Rain had wash'd from the Copperas stones, I did, by putting into it a convenient quantity of Copper reduc'd into small parts, make the newly mentioned Liquor serve for a Menstruum to work upon the Metal, and by exhaling the Solution to a dew consistence, I obtain'd the Blew Venereal Vitriol I desired. And the like, I doubt not, may be done with such of those common Green Vitriols made of Iron, wherein the Saline part is not too much satiated with the Martial.

An ingenious and well known Person, that is a great Dealer in Cider, coming to visit me, and expressing a great desire to be able to make some that would be stronger, and thereby likelier to keep longer than the ordinary way, I *ex tempore* directed him to an unusual course, for which he afterwards came to give me solemn Thanks. The way was to take the strained Juice of Apples, and in 10 or 12 Gallons thereof to steep for 24 hours (more or lesse) about two Bushels of the same kind of Apples grossly bruised; the Apples being lightly express'd, the Infusion was (with fresh) repeated once more, (care being to be taken, that the Infusion be not made too strong and thick, which may hinder the seasonable Clarification of the Liquor.)

It was not perhaps difficult to mend this Prescription, but I give you the Account of it, as I receiv'd it from him, because he assur'd me that none of his many Trials had furnished him with Cyder so well Bodied, and so much applauded. The Cautions that belong to this Practice, and the various Applications that may be made of this way of making Vinous Liquors of Fruits, without Additions (so much as of Water,) by Infusion, and the varyings of the Experiment according to particular Cases, I must not here stay to mention.

It was not long since, that accidentally Rummaging in a dark place, where I had not of a long time been, and where
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unknown to me some Chymical Glasses, negligently stopp'd, and not written on, had been put; one of them falling down made two or three great Stains in the conspicuous part of a new Suit I had then on; and would have oblig'd me to leave it off, but that judging by the nature of the Stain that was made with some acid Spirit, I tryed, by smelling to them, whether among the other Bottles one or other had not some Urinous or otherlike Spirit; and lighting on a Liquor, which though I knew not what it was, I guess'd by the Stink to abound with volatile Salt. I bath'd the stain'd parts well with it, and in a trice restor'd them to their former Colour. And by a like way I have presently remedied the Discolorations made by some sharper and fretting Liquors, of dy'd Garments of other sorts and Materials, which those Blemishes would else have rendred altogether unfit for wearing.

Another time discoursing with a States-man of the ways whereby well-meaning Persons may be injur'd and defam'd, I undertook, that out of a Parchment-writing with his hand annex'd, I would take out all that was written above his Name, without spoiling or disfiguring the Parchment, on which I would afterward write what I pleas'd, and whereby I might make People believe that he had acknowledg'd under his Hand such things, as never came into his Thoughts. And to satisfy him of the possibility of this, I did in a few Minuts take off from the Parchment all that was written on it, without defacing the Parchment. Some attempt to free Paper from what is written upon it with *Aqua fortis*, but that by discolouring the Paper, makes men apt to suspect some intended Deceit. And for the true way of performing such an Effect, and divers others of the like nature, which I have sometimes for Curiosity prosperously experimented, I think it much fitter to be conceal'd than communicated, because if such Secrets should fall into the hands of persons inclin'd to mis-apply them, they might very much disturb

Humane

Humane Society. And therefore it is better men should want the light afforded them by such Experiments, than be brought into the danger of such Mischiefs, as they may be made to suffer by the mis-employment of such Discoveries.

I remember, that not long since, a *Virtuoso* happening to have made a Solution of Gold, wherewith he thought to make *Aurum fulminans*, thought he had cause to suspect that it had been enbas'd with Copper, and therefore would not be so fit for his work; whereupon I consider'd with my self, that a good Urinous Spirit being imployed in stead of the usual Menstruum (Oyl of Tartar,) as it would precipitate Gold out of *Aqua Regis*, so it would readily dissolve Copper, I conjectured, that by the affusion of such a Liquor I might both discover whether the Solution (whose colour did not at all accuse it) contain'd any Copper, and if it did free the Gold in great part from the baser Metal: and indeed I found, that after the Urinous Spirit had precipitated the Gold into a fine *Calx*, the supernatant Liquor was highly ting'd with Blew, that betray'd the Alloy of Copper, that did not before appear.

I hope you think, *Pyrophilus*, that tis because these Instances are more pertinent to my Design, than many others (that might have been substituted) in themselves more valuable, that I have mention'd such inconsiderable ones; and I shall not repent the naming of such Instances, if they have let you see, that even mean Experiments are not to be despised, but that the meanest may be sometimes not onely useful, but more proper to convince Strangers to Natural Philosophie of the manifold Uses of it, than Experiments of a higher and abstruser nature. For as in a Shipwrack, it may more advantage the distressed Pilot to know the supporting nature of a Bladder fill'd with Wind, though otherwise but a despicable and airy thing, than to know the abstrusest

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properties

properties of the Magnetick Needles; so in some cases the more obvious and slight Experiments may be much more welcome and serviceable to us, than others at other times much more considerable. So true is that of the Wise man, *That every thing is beautiful in its Season:*

For my part, I am very apt to hope, that Natural Philosophy will prove *more* and *more* serviceable, both to single Persons in their particular Occasions, and to Trades themselves in General: as by other ways, so especially by making a further search into, and thereby detecting new Qualities, or discovering unheeded Uses, of the Productions of Nature, and of Art that are already known.

I will not here take notice of what may be further hoped for in the detection of the Medical Virtues of things, because I treat of that Subject in a more proper place: and as for the Mechanical Uses (if I may so call them) and Applications of the works and Laws of Nature, *though* he that gazes upon the seemingly great variety of Productions to be met with among Tradesmen, and in the Shops of Artificers, may be tempted to think, that Art has curiously pryed into, and imployed, almost all the Materials that Nature could afford it; *yet* he that shall more narrowly and severely consider them, may easily discern, that Tradesmen have really dealt with but very few of Natures Productions, in comparison of those they have left unimployed; and that for the most part they have, in the things they daily converse with, scarce made use of any other, than the more obvious Qualities of them; besides some few more lurking Properties, which either Chance, or a lucky Sagacity, rather than Inquisitiveness or Skill, discover'd to them. And indeed this great variety of Productions we have mentioned, proceeds more from a Manual dexterity of Diversifying a small number of known things into differing shapes, than, *either* from the Plenty of Natural or Artificial Productions they work up-
on,

only, or any diligent or accurate Search made into the Qualities of those Productions. But because to a Considering man, it cannot but be Obvious enough, that the Uses of the things they deal in, and much more those of other Concretes, which they are not engag'd to observe, have not been hitherto sufficiently enquir'd into, I shall content my self to add, That if men were but sensible enough of their own Interest, and in order thereunto would keep their Eyes heedfully open, partly upon the Properties of things, and partly upon the Applications that may be made of those Properties to this or that use in humane life, they might not only discover new Qualities in things, (some of which might occasion new Trades,) but make such Uses of them, as the Discoverers themselves would never before hand have suspected or imagin'd: whereof I may, God permitting, give you elsewhere divers Instances.

THE VII. SECTION.

After the foregoing general Considerations (about the Usefulness of Natural Philosophy to the Empire of Man over things Corporeal,) which I thought fit to take notice of in this *I. Essay*, it remains, *Pyroph.* that I also add a word or two about *those* that are to follow.

And first you must not expect that I should Methodically enumerate, and particularly discourse to you of all the Grounds and Motives I may have of looking for great Advantages to accrue to Mankind, by Mens future progresses in the discovery of Nature. To entertain You with Considerations, which perchance you would judg but Speculative and remote Concepts, would exceed my leisure, and perhaps be unwelcome to You: and therefore I choole to confine my self to the insisting on those Grounds of Expectation, which I can render probable by Examples and In-

stances of what is already actually attain'd to, or at least very likely (in no long time) to be so. And this Advertisement I thought necessary to premise, partly indeed that you may not think that I have overlook'd all the particulars pertinent to my Subject that I shall leave unmention'd, but much more that you might not suspect, that there are no other Inducements to hope much from Experimental Philosophie, than those you will find treated of in the following Essayes. And this one thing in particular I dare not forbear to give you notice of, that for the freshly intimated reason, you will there find omitted one of the principal Grounds of hoping great matters from improv'd Physiologie, namely, that by the sagacity and freedom of the Lord *Verulam*, and other Lights of this Age, considering men are pretty well enabled both to make Discoveries, and discern a possibility of removing all the Impediments and other causes of Barrenness that have hitherto kept Physicks from being considerably useful to Mankind; such as *many* false and fruitlesse Doctrines of the Schools; *the* prejudices by which men have been hitherto impos'd on about Substantial Forms, the unpassable bounds of Nature, the essential difference betwixt Natural and Artificial things &c. *a* too plausible despondency; *a* want of belief that Physicks much concern'd their Interests; *want* of Encouragement; *want* of Natural History; *want* of Curiosity; *want* of a method of Enquiring; *want* of a Method of Experimenting; *want* of a Physical *Logick*; *want* of Mathematicks, and Mechanicks; *want* of associated Endeavours; to all which but too many other particulars might be added.

2. You will not think it strange, that in the following Tracts much of the Usefulness, for which I would recommend Physicks, supposes future Proficiency in them, if you consider the nature of my Design; which is not to make an *Elogium* of Natural Philosophy imperfect as it *yet is*, but to shew

show that as it *may be*, and probably *will be*, improv'd, it may afford considerable advantages to Mankind. And since, as I long agoe intimated to you, my purpose in this Book is to invite you, and assist you to invite other Ingenious men to a farther study of Nature, tis very agreeable to my Design to represent the greatest Benefits I make it promise You, as Effects and Recompences of your future Attainments; and I should allowably enough discharge my part in this Treatise, if I should not do any more (which yet I hope I shall do) than give you Reasonable inducements to entertain high Expectations of the Fruits, that may be gathered from Natural Philosophie, if it be industriously and skilfully cultivated: and the very rendring such an Expectation probable, I take to be a good step towards the attainment of the things expected; many of which would questionlesse be obtain'd, if men were throughly perswaded that they are most worthy to be endeavour'd, and very possible to be compass'd. And therefore I wonder not, that so Judicious a Friend to Philosophie and Mankind as Sir Francis Bacon, should in several places represent mens Opinions of the Impossibility of doing Great matters of the nature of those things we are speaking of, as One of the chief Obstacles to the advancement of real and useful Learning: and I the rather insist on the things that may heighten your Expectations, *not onely* because many prudent and Learned men, who have been bred in the Philosophie of the Schools, are apt to judg of all Philosophie by that which for so many Ages has been barren, as to useful Productions, (though fruitful enough in Controversies,) *but* because I have met with some morose Authors, and others as despondent persons, who because they have unsuccessfully attempted to perform some things according to the Prescriptions of some unfaithful Writers of Natural Philosophie, fall presently to believe themselves, and to perswade others, That nothing Considerable is now (at least without

almost insuperable difficulties) to be perform'd by Natural Philosophie it self, especially whilst men amuse themselves about Speculations and Trials that seem not to tend directly to Practice; our Ancestors having had the luck to light upon all the *profitable* Inventions, which skill in Physiologie is able to supply Mankind with. But (to take notice first of what was last suggested) *I* make no doubt but that many Experiments, whereby men are not presently enabled to do what they could not before, may yet be very useful to mens interests by discovering or illustrating the Nature or Causes of things. For though that famous Distinction, introduced by the Lord *Verulam*, whereby Experiments are sorted into *Luciferous* and *Fructiferous*, may be (if rightly understood) of commendable Use; yet it would much mislead those that should so understand it, as if *Fructiferous* Experiments did so meerly advantage our interests, as not to promote our Knowledge; or the Experiments called *Luciferous*, did so barely enrich our Understandings, as to be no other waies useful. For though some Experiments may be fitly enough call'd *Luciferous*, and others *Fructiferous*, because the more obvious and immediate Effect of the One is to discover to us Physiological Truths, and of the other to enable us to perform something of Use to the Possessor; yet certainly there are few *Fructiferous* Experiments, which may not readily become *Luciferous* to the attentive Considerer of them. For by being able to produce unusual Effects, they either hint to us the Causes of them, or at least acquaint us with some of the Properties or Qualities of the things concurring to the production of such Effects. And on the other side those Experiments, whose more obvious use is to detect to us the Nature or Causes of things, may be, though lesse directly, and in somewhat a remoter way, exceedingly *Fructiferous*. For since, as *I* have formerly observ'd, man's Power over the Creatures consists in his Knowledge of them; what-

whatever does increase his Knowledge, does proportionately increase his Power. And perhaps I should not much Hyperbolize, if I should venture to say, that there is scarce any considerable Physical Truth, which is not, as it were, teeming with profitable Inventions, and may not by humane Skill and industry be made the fruitful Mother of divers things useful, either to Mankind in general, or at least to the particular Discoverer and dexterous Applyer of that Truth. To countenance this Opinion of Mine, I have already given you some instances, and reserve more for the last Essayes of this Treatise; especially having observ'd it to have been a fault, which though prejudicial enough to the interest of Mankind, is very incident to the more sober and severe sort of Philosophers, and perhaps more to Them, than to Others, to conclude every thing to be Impossible, or at least unfit to be attempted, that cannot be perform'd by the already known Qualities of Things and Wayes of applying them: without considering, That as many Simples of excellent Virtues grow in Wilderesses, and not by the Highways side, so diverse admirable Properties of things may be found, out of the customary progresse or beaten Rodes (if I may so speak) of Nature. And that Philosophers are oftentimes deceiv'd, when they think they have made a true and perfect *Analysis* of the possible wayes, whereby such and such Effects may be produc'd. For Nature by her Subtlety oftentimes transcends and illudes the greatest subtlety of humane Ratiocinations. And as she may have quite other wayes of working, than we are aware of, so the knowledge of some peculiar and conceal'd property of a Thing, may enable them that are acquainted with it, to perform that with ease, which by the known Qualities of things, is either not at all to be perform'd, or not without great Difficulty.

This seeming Paradox you may find in due place confirm'd; and in the mean while to return to those Learned men

Numb. 13 and
14.

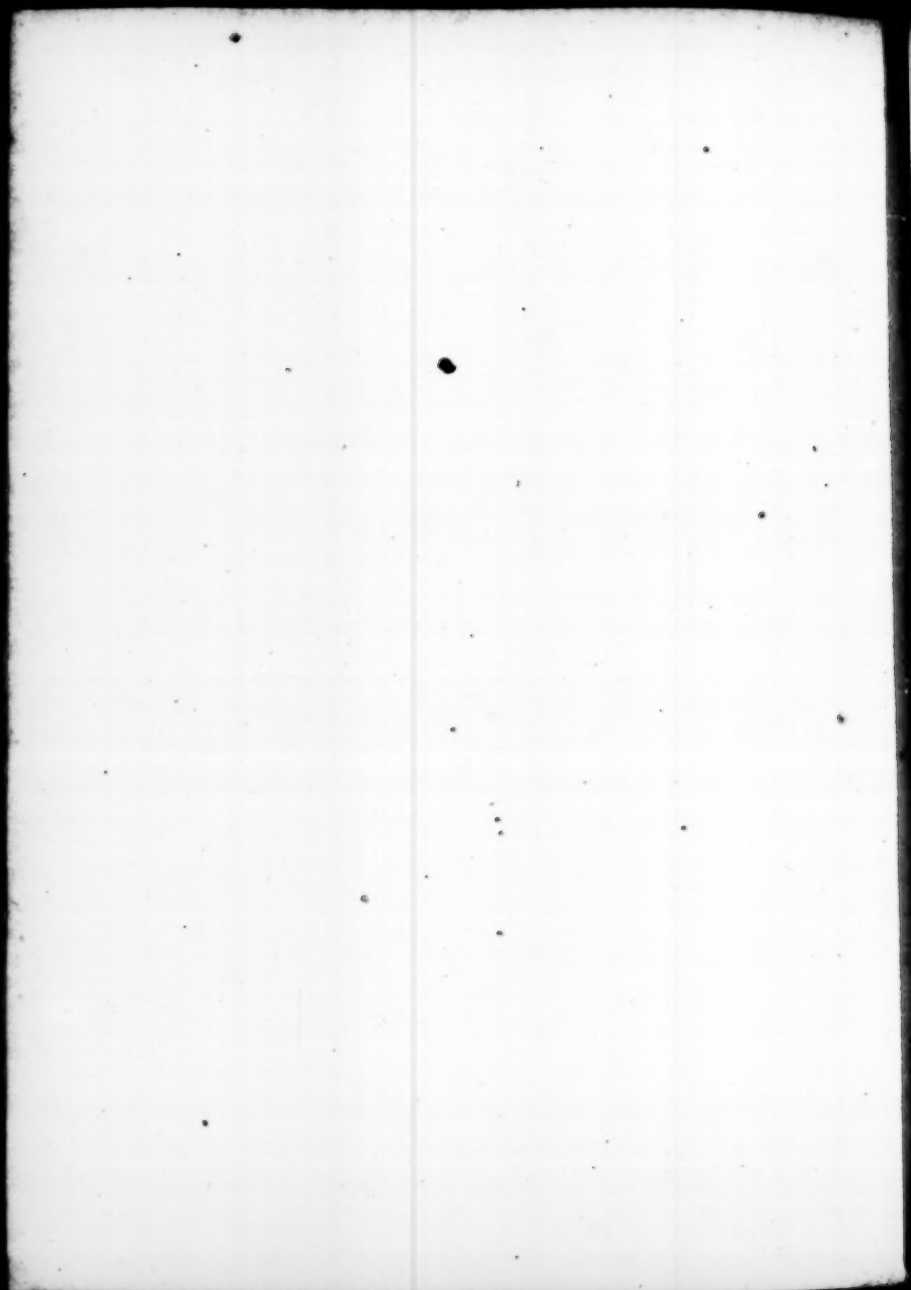
men, who having attempted some things, and possibly perform'd a few in Natural Philosophy, would keep the world from expecting any great matters from it, I shall venture to say of them, That *as* the Jewish Spies though they brought their Countrey-men out of the Land of *Canaan* some few of the goodly Fruits of that Soyl, yet bringing them withall a discouraging account of the difficulties they were like to meet with in conquering it, did the *Israelites* more harm by their Despondency, than Good by their Fruits; so divers of the Authors we are speaking of, though they may have presented us with some acceptable Fruits of their Enquiry into Experimental Learning, yet by bringing up an ill report concerning the studie of it, and thereby deterring irresolute Persons from addic'ting themselves seriously to it, they have more prejudic'd them by their Despondency, than advantag'd them by their Experiments. And though I dare not, a Chymist would not, scruple to pursue the *Simile*, and tell you, that as onely those two of the Spies, *Caleb* and *Jeshua*, who made no doubt but that they should conquer the fertile (though never so well fortified) Land of *Canaan*, did really possess it, all their disanimatèd Brethren wandring and dying in the *Wildernesse*; so none but those Generous Attempters, that dare boldly venture upon the Difficulties that surround the knowledg of Nature, are like prosperously to overcome them, and possesse what they contend for.

Numb. 14. 28,
29, 30.

But I must leave this Digression to proceed to the last Advertisement I am to give you, which is, that I know you may (possibly) expect that I should say something to You distinctly of the chief Means by which the Naturalist may probably advance Trades, and assist Man, by the blessing of the Author of Nature, to recover part of his lost Empire over the works of Nature. And I confesse, I have more than once had thoughts of a kind of Project (if I may so call it) for the Advance of Experimental Philosophy, consisting
of

of such Heads as these: A Prospect of what probably MAY be attain'd to in Physicks (both as to Theory and Practice.) A summary account of What IS attain'd already. *The Imperfectness* of our present attainments. *What* Helps men now enjoy. *The Incompetency* of our present Helps. *The Hindrances* and the Causes of them. And *The Means* and Helps that MAY be employ'd. To which other Heads might in case of need be added. But notwithstanding the expectations you may have, that I should handle such subjects, and the Thoughts I have had about them, I purposely wav'd the treating of them by themselves in the ensuing ESSAYES, *partly*, because these unelaborate Discourses are not design'd for a just Treatise on the Subjects handled in them, containing but such loose Experiments and Observations, as could without too much impoverishing other Papers, be put together on this occasion; and *partly*, because I have in effect bin careful to mention several of those things, that you might expect to find separately treated of; but knowing that a far lesse discerning eye than yours may easily, if there be occasion, distinguish them, I thought it more convenient to interweave them with the other parts of the following Discourse, since every proposition of a probable way to Improve Philosophie, is also a ground of expecting those advantages that may be hop'd for from Philosophie Improved.





Of the USEFULNESSE of
MATHEMATICKS
TO
Natural Philosophy.

OF THE VARIATIONS OF
MATHEMATICS
TO
Natural Philosophy.

Of the Usefulness of MATHEMATICKS to
NATURAL PHILOSOPHIE,

OR

That the Empire of Man may be promoted by the Naturalist's
skill in Mathematicks, (as well Pure, as Mixt.)

IF it were not allowable for any but those that are thoroughly skill'd in the abstruser Mysteries of the Mathematicks, to discourse of those Disciplines; the Title of this Essay would I fear (*Pyrophilus*) make you think me guilty of Presumption. since you may perchance remember, that when you were conversant about those Studies, I confess'd to you, that the great Authority of some famous Modern Naturalists had, for a while, diverted me from making any great Progress in those Sciences, by their resolute denying them to be useful to Physiologie. But as I do not pretend to have taken that pains, which else I might have done, to become a Speculative Geometrician; so I consider, that without understanding as much of the abstruser part of Geometrie, as *Archimedes*, or *Apollonius*, one may understand enough to be assisted by it in the Contemplation of Nature, and that one needs not know the profoundest Mysteries of it, to be able to discern its Usefulness. And therefore I shall venture to propound something to you concerning this last nam'd Subject, especially since otherwise you may be influenc'd, as I once was, by the great Authority of those Modern Philosophers, who would have the use of Mathematicks, as Disciplines that consider onely Abstracted Quantity and Figure, to be rather hurtful than advantageous to a Naturalist, the Object of whose Studies ought to be

Matter. But though these endeavour to keep men from thinking the Mathematicks to be of any great Use toward making a Man a good Naturalist, by alledging the extravagant Opinions that *Kepler* himself, who was Mathematician to three Emperours, and some other Modern Astronomers, have broach'd or maintain'd concerning matters Physiological; yet I confesse, that after I began, by reflecting upon divers of my Experiments, especially Mechanical, to discern how useful Mathematicks may be made to Physicks, I have often wish'd that I had imploy'd about the Speculative part of Geometrie, and the cultivating of the Specious Algebra I had been taught very young, a good part of that Time and Industry that I spent about Surveying and Fortification, (of which I remember I once wrot an entire Treatise) and other Practick parts of Mathematicks. And indeed I think, that a Competent Knowledge in Mathematicks (for a Profound one is not always necessary) may be so serviceable to those that would become Philosophers, that I shall not scruple to mention it as another thing which may increase your Expectation from Physiologie, That those who pass for Naturalists have, for the most part, been very little, or not at all, vers'd in the Mathematicks, if not also Jealous of them. And I the less scruple to write to you on this Subject, because I do not know that others have prevented me: For though the Learned *Clavius*, and some other Expositors of *Euclid*, have said much of the Usefulness of Geometrie to other Mathematical Disciplines, and though not a little has been said in the praise of Mathematicks in general; yet tis left free for me to discourse to you of (what is the Subject of this Essay) the Utility of Mathematicks in reference to Modern Physicks, and therein not onely to the Notions of the Corpuscular Philosophie, but even to Practical and Experimental Knowledge.

Now there are are several Scores, upon which skill in Mathematicks

thematically may be useful to the Experimental Philosopher. For there are some general Advantages, which Mathematicks may bring to the Minds of men, to whatever Study they apply themselves, and consequently to the Students of Natural Philosophie; namely, that these Disciplines are wont to make men accurate, and very attentive to the Employment they are about, keeping their Thoughts from wandering, and inuring them to Patience of going through with tedious and intricate Demonstrations; besides, that they much improve Reason, by accustoming the mind to deduce successive Consequences, and judg of them without easily acquiescing in any thing but Demonstration.

And indeed the Operations of Symbolical Arithmetick (or the modern Algebra) seem to me to afford men one of the clearest Exercises of Reason that I ever yet met with, nothing being there to be perform'd without strict and watchful Ratiocination, and the whole method and progress of that appearing at once upon the Paper when the Operation is finish'd, and affording the *Analyst* a lasting, and, as it were, visible Ratiocination.

But, *Pyrophilus*, I may not insist on these, or the like general Uses of pure Mathematicks, since there are divers others, which more immediately respect Natural Philosophie.

And to shew this the better, give me leave to premise to the following Particulars a couple of Observations.

The first is, That the *Phænomena*, which the Mathematician concurs to exhibit, do really belong to the Cognizance of the Naturalist. For when Matter comes once to be endow'd with Qualities, the Consideration how it came by them, is a Question rather about the Agent or Efficient, than the nature of the Body it self. So the Image or Picture, that a man sees of his Face in a Looking Glass, though that be an Artificial Body, falls as well under the Speculation of the Naturalist, as when the like Picture is presented him by
calm

calm and clear Water. And the Rain-Bows that are often artificially made in Grotto's; by dispersing the water of Fountains into Drops and Showers, have a just Title to his Contemplation, as well as the Rain-bow that is form'd in the Clouds. And the Eccho's that are admir'd in some of those Grotto's, purposely and artificially contriv'd to afford rare ones, do as well belong to his cognizance, as those that Nature makes in ruder Dens, and other Cavities of Hills and Mountains. And indeed most of those *Phænomena* require (for the main) the same Solutions, whether the skill of man do or do not intervene to exhibit them.

The second Consideration, which I am often oblig'd to repeat, is this; That since Man's power over the Creatures depends chiefly upon his Knowledge of them, whatever serves to increase considerably his Knowledge, is likely either directly or in its consequences to adde to his Power; which two Advertisements being thus given you, *Pyrophilus*, I now advance to the particulars, whose mention they made me suspend.

I. And first, these Disciplines teach men the Nature and Properties of Figures, both upon Surfaces and Solids, and the Relations (for they can scarce be properly called *Proportions*) betwixt the Surface and Solidity of the same Body. 'Tis true, that *Matter*, or Body, is the subject of the Naturalist's Speculations; but if it be also true, that most, if not all the Operations of the parcels of that Matter (that is, of Natural Bodies) one upon another, depend upon those Modifications, which their Local Motion receives from their Magnitude and their Figure, as the chief Mechanical Affections of the parts of Matter; it can scarce be denied, that the knowledge of what *Figures* are, (for instance) more or less capacious, and advantag'd or disadvantage'd, for Motion or for Rest, or for penetrating or resisting Penetration, or for the being fasten'd to another &c. must be of considerable Use
in

in explicating many of the *Phænomena* of Nature; and tis sufficiently known, how much of the Doctrine of Figures may be learn'd from Geometricians, who treating expressly and copiously of Triangles, Circles, Surfaces Elliptical, Parabolical, Hyperbolical, and other plain Figures; as also of Spheres, Cones, Cylinders, and especially Prisms, Pyramids, Cubes, and regular Bodies, intimate also the Methods of judging of the Figures of other Bodies, that are either compos'd of them, or may, by reason of some Analogie, be refer'd to them.

There are divers Properties as well of Planes and Solid figures, and their Habitudes to each other; as of such Lines as are describ'd by Motions, or wherein Motions may be made: the knowledg whereof may be of good use not onely to the Speculative Naturalist, but the Practical.

To know the Proportion that *Archimedes* has demonstrated to be between a Sphere and a Cylinder, and either of those to a Cone so and so qualified; or to know, that a Triangular Pyramid is the third part of a Prisme, having the same Base and Height; and in a word, to know the Proportions between Geometrical Bodies, may sometimes be of good use, in cases where we can procure the one, and not the other, or at least not so well as the other. Of this an Instance is given us by the Ingenious *Marinus Ghetaldus*, (as I find him cited by a late Mathematician) who tels us, that *Ghetaldus* finding it very difficult to procure an exact Metalline Sphere, wherewith to examine the proportion in point of weight between heavy Bodies of the same Bulk, found that yet he could get a Cylinder of Tin to be turn'd true; and having therewith made his Experiments or Observations, 'twas easie for him, knowing out of his *Archimedes*, that the proportion of a Cylinder, whose Basis is equal to one of the great Circles of a Sphere, and whose Height is equal to the Diameter of that Sphere, is to that Sphere in

ratione

ratione sesquialtera, as they speak, *i.e.* has the same proportion that three has to two; it was, I say, easie for him, who had often had occasion to weigh his Cylinder exactly, by subtracting a third part of the whole weight, to find in the remainder the desir'd weight of a Sphere of Tin, whose Diameter was equal to that of the Basis, or to the height of the Cylinder: which weight of a Sphere of a known Diameter being once obtain'd, he deduc'd from them the weights of the other Spheres he had occasion to imploy, about the construction of those Tables, which have been much made use of by divers succeeding Mathematicians. And what Applications I have made of the same *Archimedean* Theorem, I may elsewhere inform you.

It being also taken for granted by divers Modern Geometricians and Engineers, that the Excellent *Galilao*, and his not degenerate Disciple, *Torricellius*, had demonstrated the Line which a Heavy body, projected, and even the Bullet, shot out of a Cannon, describes, to be Parabolical; it may be of moment in the practice of Gunnery, and in reference to divers Experiments to be made with other projected Bodies, to be well vers'd in the nature of the Parabola and Parabolical Lines, which are also thought to be capable of doing Wonders in Burning-glasses, in case these Metalline *Specula* can be brought to a Parabolical Figure; one of whose remarkable properties is, That all the Beams that, being parallel to the *Axis*, fall upon the Internal Superficies, are reflected to one point or *focus*; where consequently, if the Burning-glass be any thing large, the Heat must be very intense, especially in comparison of a Spherical Burning-glass of the same bigness.

And as for delightful and Recreative Experiments, you will easily allow me, that there are abundance of Catoptrical ones of that sort, which depend upon the figure of Spherical, Cylindrical, and other sorts of Reflecting Glasses.

2. I might here tell you, *Pyrophilus*, that pure Mathematicks themselves, setting aside the assistance they are wont to give to mixt Mathematicks, may be of use to Humane Life, and to the Experimental Naturalist; of which I shall give you, as a Specimen, this notable Example.

The properties of Arithmetical and Geometrical Progressions in Numbers, seem to have very little to do with the Practice of weighing out things in Shops and Warehouses. And yet by the knowledg of the Double Progression, beginning from an Unite, (as Arithmeticians call that, wherein the Consequent is still double to the Antecedent) as 1.2.4.8. a great deal of Cumber, and sometimes of Charge, may be sav'd. For with 3 Weights you may weigh all the Pounds, that are from 1 to 7 inclusively; with 4 Weights, all those that exceed not 15 pound; upon which observation is grounded the Division of some Boxes or Sets of Weights, us'd by our Goldsmiths. And if you would, as is very usual, put Weights (when there is occasion) in both Scales, to help the thing to be weigh'd to bring the Balance to an *Equilibrium*, then the Triple Progression (*i. e.* where the Numbers increase in a triple proportion, as 1. 3. 9.) has a much more notable property for our purpose; by considering which, the Industrious *Stifelius* concluded, that by 3 Weights, you may weigh any number of Pounds from One to 13 inclusively; with 4 Weights, any number of pounds from 1 to 40 inclusively; with 5 Weights, any number of pounds not exceeding Sixscore and One; and with but 6 Weights, any number of pounds from 1 to 364. But the method of ordering so few Weights to serve so many purposes, is best found out by Symbolical Arithmetick, or Algebra, by which I have taken pleasure to work so fine a Problem; which, because tis applicable not onely to Pounds,

8 *Of the Usefulness of Mathematicks*

but to the parts of pounds, and those of differing Denominations, it may be of so great Use to you, if ever you busie your self about Statical Experiments, that I shall to the end of this Essay annex a Table, to shew, what Weights are to be taken in every possible case, which I found ready calculated to my hand by the Ingenious *Franciscus a Schooten*, Professor of Mathematicks at *Leyden*.

To the former Instance, of the Use that an Experimenter may make of pure Mathematicks, I might, if it could be sufficiently deliver'd in few words, adde the method of computing the Combinations, that may be made of any number of things propos'd, which some Mathematicians call *Regula Combinatoria*. For though I remember not to have found this Method fully handled in any one Author, even among the modern Algebricians; yet, as it is deliver'd by some Arithmeticians, it is by no means to be despis'd, but, as it may be managed by Symbolical Arithmetick, it will, if I mistake not, want nothing, but the being skilfully applied by the Naturalist, to be on certain occasions very serviceable to him.

3. We may take notice in the next place, that Mathematicks may much help the Naturalist, both to frame *Hypotheses*, and judg of those that are propos'd to him, especially such as relate to Mathematical subjects in conjunction with others.

What wretched Theories the Ignorance of Mathematicks has made Naturalists, otherwise very considerable in their way, frame and propose, may be evidently shewn in the Accounts that *Epicurus*, and his Paraphrast *Lucretius*, give of the Sun, and other Celestial Bodies. And indeed what satisfactory Account can be given of the varying Lengths and Vicissitudes of Dayes and Nights, and the Eclipses of the Sun

Sun and Moon, the Stations and Retrogradations observ'd in Planets, and other familiar Coelestial *Phænomena*, without supposing these great Mundan Bodies to have such Scituations in respect to one another, and to move in such Lines, (or at least be made to appear to move in them by the motion of the Earth in such a position, and in such Lines?) nay how without the knowledg of the Doctrine of the Sphere will the Naturalist be able to make any sober and well grounded Judgment in that grand and noble Problem, *which is the true Systeme of the World?* which is indeavour'd to be solv'd after such differing manners by the *Ptolomaans* and *Peripateticks*, by the *Tychonians* and by the *Copernicans* (both lesse and more modern.)

That (then) the knowledg of Celestial Bodies is not well to be attain'd, nor consequently the Theories, propos'd of them, to be intelligently judg'd of, without Arithmetick and Geometrie, (those Wings, on which the Astronomer soars as high as Heaven,) he must be very little acquainted with Astronomie, and particularly with the various, and, too often, intricate Theories of Planets, that can doubt. And truly, when I consider the astonishing distance and immensity of the Celestial Bodies, and those almost numberles fix'd Stars (each of them perhaps much vaster than the whole Earth,) which in a clear Night I take pleasure to gaze at through the better sort of Telescopes, both in the Milky way, and in other parts of the Sky, that seem not so much as whitish to our Eyes; I cannot but highly prize a Science, that acquaints us, that what we know of so much of the Universe as the Globe we inhabit and call the World, is but a Point to it, taking up a little more room in it, than a Physical Center in the Sphere.

The Usefulness also of pure Mathematicks to Geographie is likewise evident; and sure inquisitive men ought not to

despise this and the former part of Learning, without which, as I was lately saying, they cannot know so much as whether the Earth we live upon, moves or stands still?

There are also divers *Phænomena* of Nature, that are neither Astronomical, nor Geographical, where the Usefulness of Mathematicks is manifest enough. For as to the *Phænomena* of that Sense, to which the Naturalist is most beholding, *Sight*, what a pittiful Account is given of them by those *Aristotelians*, Physicians, and other Writers, without excepting many good Anatomists, that have been strangers to Mathematicks, in comparison of what has been done (not to mention *Euclid*, *Alhazen*, and *Vitelius*) by *Kepler*, *Scheiner*, *Herrigon*, and some other modern Mathematicians.

And tis evident to those that are acquainted with Dioptricks, that without some knowledg not onely of the properties of Convex Bodies, and of the Laws of Refraction from and towards the Perpendicular, (as the Masters of Opticks speak) but also of the properties of Lines, as Circular, Parabolical, Hyperbolical, &c. and Figures, as Ellipses, Circles, Parabola's, Hyperbola's, &c. tis almost impossible, either well to explicate most of the *Phænomena* of that noblest of our Senses, *Sight* it self, or to make a well grounded judgment of others Explications of them. He that is altogether a Stranger to this part of Mathematicks, will scarce be able to conceive the Reason of the admirable Fabrick of the Eye, and how the Chrystalline Humor does by its Convex Figure (like a Lenticular Glass) refract and converge the Beams, (or at least the Pencils) that proceed from the visible Object, that they may paint the more lively picture of it upon the *Retina* at the bottom of the Eye: nor will he understand why, by reason of the Decussation of the
Beams

Beams within the Eye, this Picture must be made inverted, though we apprehend the Objects themselves in a right posture; nor why small Objects, plac'd near the Eye, where they are seen under a wide Angle, appear as big, as very much greater that are seen at a greater distance from it. And much less will he be able to understand the reason of those many Delusive Apparitions, exhibited by Concave, Convex, Conical, and Cylindrical Glasses, the Catoptricks, or *Doctrine of Reflex vision*, belonging yet more to the Mathematicks than Dioptricks do.

4. And *since* that from the Magnitudes of divers Bodies, or of several parts of the same Body, and so likewise from their degrees of Celerity in their Motion, there will arise a certain Respect, which if they be but two, Geometricians call a *Ratio*, and if more than two, a *Proportion*, (though these Terms are oftentimes confounded, and promiscuously employ'd by Authors:) and *since* Proportion is so frequently to be met with in the Works of Him, who by an Eminent, though Apocryphal Writer, is truly said to have *made all things in Number, Weight, and Measure*; and *since* the Doctrine of Proportion, as such, belongs to the Mathematician as the Noblest part of those Sciences he treats of; I think it may safely enough be affirm'd, that he that is not so much as indifferently skill'd in Mathematicks, can hardly be more than indifferently skill'd in the fundamental principles of Physiologie. Nor perhaps would it be rash to say, that the Fifth Book of *Euclid's Elements*, where the Doctrine of Proportions is chiefly deliver'd, may prove more instructive to the Naturalist, than the Fifth Book of *Aristotle's Physics*. And therefore I do not so much wonder, that *Plato* should over the Gate of his School place an Inscription, (*ἡ δὲ μαθηματικὴ τῆς φύσεως ἐστὶν ἀρχή*) forbidding the Entrance to persons unacquainted.

quainted with Geometrie, as unfit to judg of what was there taught.

Nay this, though you may think it strange, is very true, that there are some considerable *Phænomena* of Nature, which are so far from being Explicable by their Causes, that men cannot so much as understand what is Meant by them, without some knowledg of the Doctrine of Proportions. As, for Instance, when the Teacher of Opticks tell us, that the Increments of Light are *in duplicatâ ratione distantiarum, secundùm quas à Corporibus recedant, à quibus primum efficiuntur*. He that knows nothing of Proportions, cannot tell so much as what they mean by this Theorem, much less whether or no it be true. And so, when the same Proposition is by the diligent *Mersennus* apply'd also to Sounds, a common Reader would not at all understand him, if he did not adde by way of Explanation, that if, for Instance, the Noise of a peece of Ordinance be heard a League off, that Noise will be four times stronger, if it be heard but at the distance of half a League. Nor will this Example it self give such a Reader, as we speak of, a clear understanding of the propos'd Theorem. But a considerabler Instance in this kind may be afforded us by the noble Discovery of the Moderns, especially *Galilao*, who observe, that when a heavy Body descends through the Air, the Spaces past through, from the beginning to the end of the Motion, are among themselves in a (not double but) *duplicate* Ratio of the Moments or equal Divisions of Time spent in the fall; which requires the knowledg of what a *Duplicate* Proportion is, to be well understood: But it may in some sort be explain'd, (and so noble a *Phænomenon* must not be here omitted,) by saying, that *Galilao* affirms himself to have observ'd, that a Brass Bullet of 100 pound will, in the space of one Minute

*Harmonic. lib. 1.
Prop. 12.*

of

of an Hour, descend an hundred *Florentine* Cubits, (which some reckon to be 180 Feet of ours,) and consequently, saith *Mersennus*, four Cubits in one Second, or sixtieth part of a Minute; and by adding, that the Bullet falls in such a *Ratio*, that the acceleration of the Motion is made according to the progression of odd Numbers, beginning from an *Unit*, or One; so that if in the first moment of time the Weight fall down one Fathom, in the 2^d moment it must descend three Fathom; in the 3^d, 5 Fathom; in the 4th, 7; in the 5th, Nine; in the 6th, Eleven; and so onward. Whence *Mersennus* gives this Rule, to know how far the Weight will descend in a determinate time assign'd; and by knowing how far it has descended, to calculate how long it was in falling.

Regula generalis, says he, *hac est. Si dentur tempora, & quantantur spatia, quadrentur tempora & habebuntur rationes spatiorum. Si dentur spatia, & quantantur tempora, investigetur latus spatiorum, & dabitur ratio temporum.*

*Mersen. Har-
mon. lib. 2. Pro-
pos. 24. Corollar.
1.*

Divers other Instances might be produc'd, to manifest the requisitenes and advantagiousnes of some knowledg in Mathematicks to a Speculative Naturalist: But I shall content my self to name one more, *viz.* that the grand Theorem or Rule of the Staticks, That in the *Ballance*, or resembling Instruments, the Proportion betwixt the equivalent Weights, and their distances from the *fulcimentum* or *Prop.* is reciprocal, (so that tis usual with Butchers, and other Tradesmen, to weigh in the *Statera*, commonly call'd the *Styliards*, 10 or 20 pound weight, for Instance, hung neer the *Fulciment*, with one pound weight, plac'd on the other side of the Beam, at 10 or 20 times distance from it,) and many other Theorems, that serve to explicate the properties of the grand Instrument of Nature; Motion, (especially as produc'd or modify'd by Weight, or equivalent Force variously adapted, and

and apply'd) cannot well be understood without an Insight into Geometrie, and especially the Doctrine of Proportions; and how much the knowledge of the Principles and Theorems of the Mechanicks may assist the Naturalist both to explicate many of Natures *Phænomena*, and to try Experiments, and work great Changes on her Productions, men will then more readily confess, when they shall better discern how many of her works are but Engines, and do operate accordingly.

5. And give me leave, *Pyrophilus*, to adde in this place, that the Doctrine of Proportions, as it is the Soul of the Mathematicks themselves, so it may be of vast (though perhaps yet unheeded) Use in Physiologie too; not onely as it helps the Naturalist (as we have newly seen it does) to understand divers *Phænomena* of Nature, but as it may enable him to perform divers things, which he could not perform without it; of which, though I may have occasion to give you hereafter in other papers several Examples, yet I shall now mention two or three for Illustration sake.

That the Pendulum is the accuratest Instrument that we yet have of measuring short spaces of Time, I presume you do not doubt: and I need not tell you, that he who would know what Length a Pendulum must be of, to measure by its Swing some determinate space of Time, as, for Instance, a half Second, (or half the sixtieth part of a Minute,) must find it out by Trial and Observation, if he be not unacquainted with the Doctrine of Proportions: but in case he is vers'd in that, as well as in the *Phænomena* of Pendulums, he may from the length of one Pendulum, that exactly measures a known part of Time, without making particular Tryals and Observations, deduce the length of Pendulums that will serve to measure other Divisions of Time. For Instance, that

that diligent Observer *Mersennus* assures us, that he found by frequent Tryals, that a slender String with a Pistol or Musket Bullet at the end of it; whose Length comprehending the Bullet was 3 Foot and a half, (elsewhere he mentions 3 Foot and a 27th) vibrates Second (Minutes:) This now being taken for granted, and it being a receiv'd Theorem concerning Pendulums alike in all things but Length, *That the Lengths are in Duplicate Proportion to the times in which their Vibrations are respectively perform'd, or are as the Squares of the Vibrations they performe in the same time,* and consequently, the times are in Subduplicate Proportion to the lengths of the Pendulums; if a man would (as I was saying) have a Pendulum that shall vibrate Half-seconds, he must not take, as one unacquainted with these things would be apt to do, a Pendulum of a Foot and $\frac{1}{4}$, which is $\frac{1}{2}$ the length of that which vibrates a whole Second, for such a Pendulum would prove much too long for his purpose, nor need he by multiply'd observations laboriously find out how much it is too long, (which oftentimes for want of a Standard he cannot do,) but since the proportion between a Second and $\frac{1}{2}$ a Second is double, and the proportion betwixt the length of the Strings, that are to vibrate these two differing spaces of time, must be Duplicate of the proportion of the times themselves, it follows, that the length of the Strings must be as 4 to one, (which is the Duplicate of the proportion of 2 to 1,) and so the length of the shorter String must be but a $\frac{1}{4}$ of that of the longer.

This, if it were needful, might be confirm'd by a Probleme of the Learned *Ricciolo's*, whereof I shall here give you an Example, because I may hereafter have occasion to shew you the farther use of it. Let us then suppose, to avoid fractions, that a Pendulum that vibrates Seconds, is 3 entire

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Foot

Foot long, (as indeed some modern Mathematicians tell us it is and as it may well be according to the measure us'd in some places.) If then you multiply 3690 the Square of the Vibrations, (which are 60,) that your 3 foot Pendulum makes in a Second, by the length of the Pendulum, which is 36 Inches, and divide the Product (viz. 129600) by 9 Inches, the 4th part of the length of the former Pendulum; and if lastly, of the Quotient (14400) you extract the Square root, you shall find it to be 120, that gives you the number of Vibrations that will be made in a Second by a Pendulum of 9 Inches long, and this Root being 20, which is the double of 10, you may see, that to make a Pendulum, that shall vibrate Half-Seconds, it must be but $\frac{1}{2}$ as long as that which vibrates whole Seconds. And if I thought you were like to think these Rules as strange, as a person wholly unacquainted with the nature of Pendulums, and the Doctrine of Proportions may do; I would invite you to consult Experience, as I have purposely done in differing Pendulums, that divide a Minute into Seconds, Half seconds, and Quarter-Seconds; since though your Tryals should not be very nicely made, they may suffice to perswade you, that the above mention'd Rules are either accurately true, or at least true for the main, and therefore true enough to be very useful in many occurrences.

To the above mention'd Instances afforded by Pendulums I shall here adde but one more, that comprehends many thousands; for the Art of composing of that great variety of Harmonious Tunes, that makes Musick so delightful to us, depends upon the Doctrine of Proportions. And he that being well skill'd in that, knows how to apply it to the Notes or Words propos'd, according to the Observations which Experience has afforded, of the gratefulness of such
and

and such Consonancies &c. may out of his own head compose a strange variety of new and pleasing Tunes, which are to many Exercises that man makes of the power his Skill gives him over the Bodies of which his Musical Instruments consist, and over those which they affect.

6. I know not, *Pyrophilus*, whether I may not reckon amongst the Advantages that Mathematicks may afford the Naturalist, That they will in many cases suggest to him divers new Experiments, whereby to vary those wherein the Figures of Bodies, the Lines of Motion, as also Numbers, Proportions, and the like Affections, which the Mathematician is wont to treat of, may come into consideration. For 'tis very likely, that those suggested Experiments, which either would not be thought on, or could not be skilfully propos'd, by a person not vers'd in Mathematicks, may, either immediately, or upon the score of the Applications that may be made of them, prove serviceable to men: (of which I hope in one of the following Essays, to give you some Instances.)

See the IX
Essay.

I care not to mention to you, how great a variety of Tryals and Observations, about the best way of Levelling great Guns, and the differing Distances to which they will carry at such and such Elevations, and the Lines describ'd by the motion of the Bullet, and other particulars belonging to the Art of Gunnery, have been propos'd and try'd, upon the Hints suggested by Geometrie's Mathematical Disciples (especially,) and others, because many Good men with these fatal Arts had been less understood. And therefore I shall rather put you in mind of the great variety of *Phænomena*, which pure Mathematicks have help'd men to discover and derive from these familiar Observations, That a Beam of Light, passing through differing *Mediums*, is not continued in a streight Line, but broken or refracted; and, That in

such and such conjunctures of Circumstances the Sun or Moon will suffer an Eclipse, that will obscure such a part of the Body, and last from such a time to such a time: from which Observations of Eclipses divers very considerable things have been deduc'd by Mathematicians, not onely as to Astronomy, but also Geographie, Navigation, and Chronologie. And he that considers what the Doctrine of Proportions, and of Concords (or, as our Musicians call them, Cords,) and Discords, has contributed to the great number of Musical Instruments, that have been actually made, and delightfully practis'd, and that it may afford the Naturalist divers Hints applicable to other purposes, (which I shall hereafter have occasion to intimate,) He, I say, that considers these things, especially if he be also acquainted with Ingenious, pleasant, and some of them useful, Experiments, that have been or may be deriv'd from the Observations, That when a Beam of Light falls upon a Body, and rebounds from it, the Angle of Incidence is equal to that of Reflection; That if the Superficies of the Body be Curve, the Angle is to be estimated as if it fell upon a Tangent to that Superficies; That if the Beam penetrate the Body, and come to it through a thinner *medium*, tis refracted towards the Perpendicular, if through a thicker *medium*, from the Perpendicular; He, as I was saying, that shall consider These things, and withall what a great variety of Propositions, as well Problems as Theorems, have been deduc'd by Mathematicians by the help of these few Observations, and of as few Propositions touching the place of the Object seen by the help of Specular and Dioptrical Glasses, will easily grant; what by so many Instances I have been endeavouring to prove.

7. I come now to the Consideration, wherewith I shall conclude

conclude this Essay, *viz.* That divers Disciplines that are reckon'd amongst the mixt Mathematicks, are chiefly Practical, and may assist the Naturalist in making Experiments and Observations, which he either could not make, or could not make so accurately without them: As may appear, *partly* by the Art of Dialling, which teaches how to measure Time, and tends chiefly to practice; *partly* by the Art of Perspective, which is of great use to represent Solids and Distances upon a small and plain Superficies, and is very serviceable to the Linners Art; wherein if Schollars and Travelers were more generally conversant, the History of Nature would be far better adorn'd with lively representations of Plants, Animals, Meteors, &c. and also *by* several parts of the Art of Navigation, and particularly that which they call *Hifriodromia*, or the Doctrine of the Lines by which Pilots make their Ships to sail. Now if in these, and divers other Instances that may be given, it must be acknowledg'd, that mixt Mathematicks may be serviceable to the Naturalist, and assist him to promote the Empire of Man; it ought not to be denied, that pure Mathematicks themselves, as vulgar Arithmetick, Geometrie, and Algebra, may be of Use to the Naturalist, since tis from those Speculative parts of the Mathematicks, that not onely these other more Practical Disciplines are deriv'd; but a greater number of those Disciplines that are called mixt Mathematicks, may, according to what I elsewhere observe, be hoped for. For *as* Sounds and pure Mathematicks make up Musick, and Water with the same Sciences make Hydrostaticks; *so*, as I elsewhere note, by a further Application of the same parts of Knowledge to other Subjects, (and in some cases even to the *same*;) those Disciplines that are call'd Mixt Mathematicks, may be advanc'd probably as to Number, as well as certainly as to Usefulness

Usefulnesses and Variety of Experiments. Nor is it only in those parts of Learning, that I have now particularly nam'd, that useful Applications may be made of the Theorems and Problems of pure Mathematicks, since upon these sublime Sciences do also in great part depend those other Mathematical Disciplines, which are wont (by a *Synecdoche*) to be call'd Mechanical, and which tis now time that I passe on to consider.

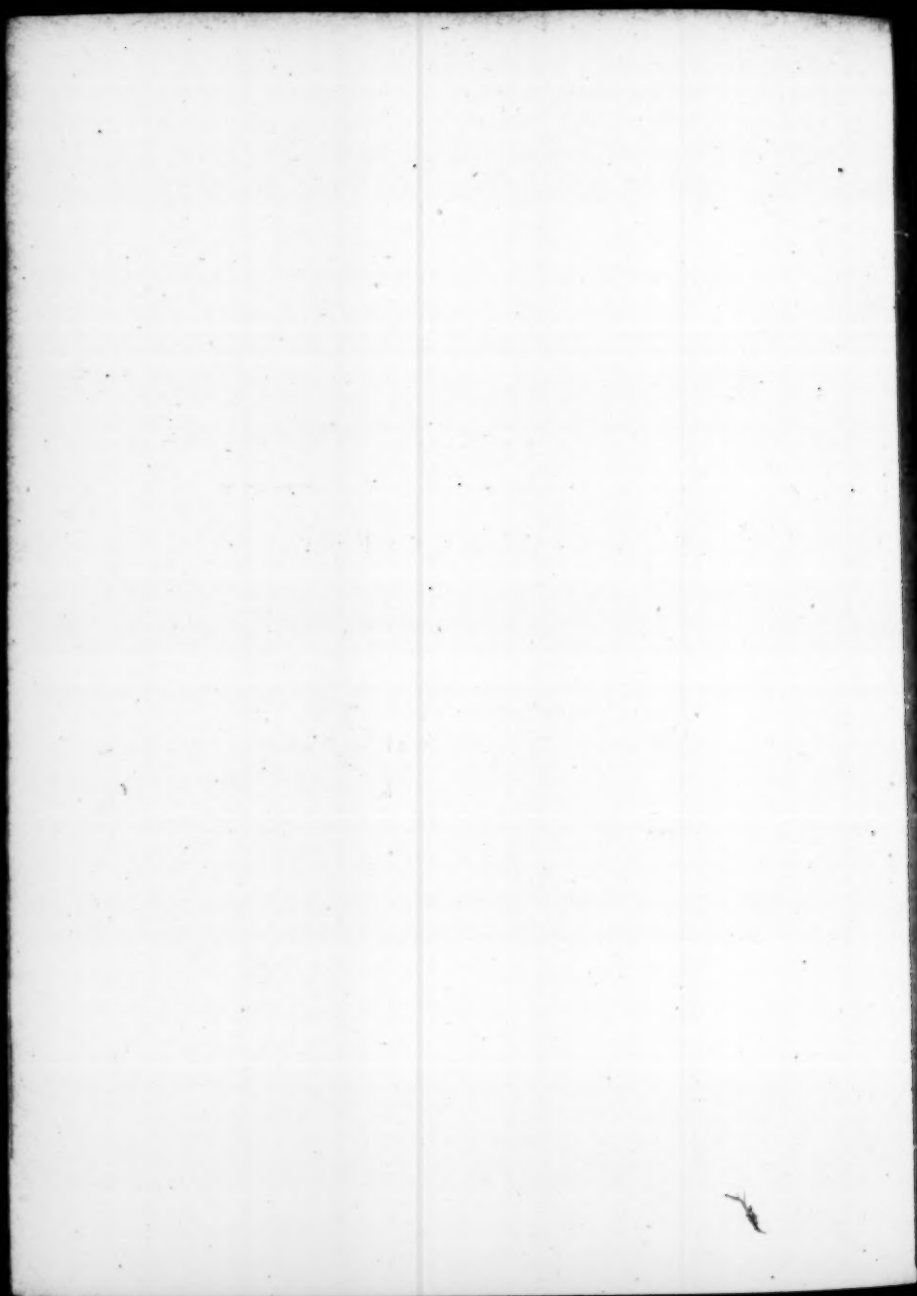




MR BOYLE'S
} EXPERIMENTAL
} Philosophie. } Vol: II.

Of the V^SEFULNESSE of
MECHANICAL Disciplines
TO
Natural Philosophy.

A





Of the Usefulness of Mechanical Disciplines to
 NATURAL PHILOSOPHIE,

SHEWING

That the Power of Man may be much promoted by the Naturalist's skill in Mechanicks.

TO prevent the danger of Stumbling (as they speak) at the Threshold, I shall begin this Discourse with advertising you, that I do not here take the Term *Mechanicks* in that stricter and more proper sense, wherein tis wont to be taken, when tis us'd onely to signifie the Doctrine about the Moving Powers (as the Beam, the Leaver, the Screws, and the Wedg,) and of framing Engines to multiply Force; but I here understand the word *Mechanicks* in a larger sense, for those Disciplines that consist of the Applications of pure Mathematicks to produce or modifie Motion in inferior Bodies: so that in this sense they comprise not onely the vulgar Staticks, but divers other Disciplines, such as the Centrobarricks, Hydraulicks, Pneumaticks, Hydrostaticks, Balisticks, &c. the Etymologie of whose names may inform you about what Subjects they are conversant.

Now that these Arts (if you will allow them that name) may be of great Use to the Experimental Philosopher, and assist him to enlarge the Empire of Man, may be made probable by this general Consideration, That divers of those things which in the former Essay have been evinc'd to make the Mathematicks useful to the Naturalist, may be applied *mutatis mutandis* to the Mechanicks also. Besides that these Disciplines have some Advantages peculiar to themselves. But the truth of what is thus represented in general Terms,

will possibly be better discern'd, and more perswasive, if we descend to some Particulars.

I. First (then) the *Phænomena* afforded us by these Arts, ought to be lookt upon as really belonging to the History of Nature in its full and due extent. And therefore as they fall under the Cognizance of the Naturalist, and challenge his Speculation; so it may well be suppos'd, that being thoroughly understood, they cannot but much contribute to the Advancement of his Knowledge, and consequently of his Power, which we have often observ'd to be grounded upon his Knowledge, and proportionate to it. When (for instance) we see a piece of Wood, duckt under water, emerge again and float, even Vulgar Naturalists think that it belongs to them to consider the reason of this Emerfion and Floating, which they endeavour to render from the Positive Levity, which they fancy to be (upon the account of the Air and Fire) inherent in the Wood, though some Woods, that will swim in water, being put into Oyl or high rectified Spirit of Wine may sink.

But I see not why it should not belong to Philosophers to consider and investigate the Reason, why one part of floating Wood appears above the Water, whilst the other keeps beneath it, and why the extant part is equal to the immerf'd, or either greater or lesser than it in such a determinate proportion, and why the same Wood will sink deeper in some waters than in others, (as in a River than in the Sea,) as on the other side some Woods will sink lower than others in the same Water. For if these things be duely examin'd, as they may by the help of Hydrostaticks, not onely the Cause of these and the like *Phænomena* will be discovered; but by the Applications of that Discovery an easie way may be devis'd to measure and estimate the differing strength of several Salt Springs, and also of divers kinds of Lixiviums, and Brines; to which may be added divers other Practical

Corollaries

Corollaries from the same Discoveries, which I shall hereafter have occasion to particularize.

II. The Mechanical Disciplines help me to devise and judge of such *Hypotheses*, as relate to those Subjects wherein the Notions and Theorems of Mechanicks either ought necessarily to be consider'd, or may usefully be so.

Of this we have Instances, not onely in those Engines that are Artificial, and are lookt upon as purely Mechanical, as the Screw, the Crane, the Ballance, &c. but in many familiar *Phænomena*, in which the Theorems of Mechanicks are not wont to be taken notice of to have an Interest: As *in* the carrying a Pike or Musket on one's shoulder, *in* the force of Stroaks with a longer or shorter Sword or other instrument, *the* taking up and the holding a Pike or Sword at Armes-length, and the power that a Rudder has to steer a Ship; *in* rowing with Boats, *in* breaking of Sticks against ones Knee, and in a multitude of other familiar Instances, of which the Naturalist's skill in Mechanicks will enable him to give a far more clear and solid Account, than the Ancient Schoolmen or the Learned'st Physicians that are unacquainted with the Nature and Properties of the Center of Gravity, and the several kinds of Leavers, the Wedge, &c.

III. Nay there are several Doctrines about Physical things, that cannot be well explicated, and some of them not perhaps so much as understood without Mechanicks.

That which emboldens me to propose a thing that seems so Paradoxical is, That there are many *Phænomena* of Nature, whereof though the Physical Causes belong to the Consideration of the Naturalist, and may be render'd by him; yet he cannot rightly & skilfully give them without taking in the Causes *Statical*, *Hydrostatical* &c. (if I may so name them) of those *Phænomena*, i. e. such Instances as depend upon the knowledg of Mechanical Principles and Disciplines.

OF

Of This we have an obvious Example in that familiar Observation, that we partly toucht upon just now about the swimming and sinking of Wood in water. For if it be demanded, why Wood does rather swim upon water then sink to the bottom of it, a School-Philosopher would answer, that Wood abounds with Air, which being an Element very much lighter than Water, keeps it aloft upon the surface of that Liquor. But this Answer will scarce satisfie a Naturalist, vers'd in Hydrostaticks. For not now to Question what is taken for granted, that there is a positive Levity, and that the Air is endow'd with that Quality, Experience shews us, that though when Wood is not heavier than so much Water, as is equal to it in Bulk, it will swim; yet in case it be heavier than so much water it will sink. As we see in divers Woods, and particularly in *Guaicum*, which I therefore the rather name, because Chymists observe that if it be burnt, it leaves far lesse Ashes (and such are suppos'd to contain the Terrestrial and heavy parts) behind it, than many Woods that we know will float in water. And though Stones and Iron be upon the score of their weight, believ'd to be bodies that have little Air in them, yet if the Liquor into which they are put be heavier, bulk for bulk, than they, they will not sink but float, and if forcibly deprest, they will emerge, as you may try when you please, by putting Stones or Iron or the like ponderous Body upon Quick-silver, or melted Lead; so that we need not here consider whether Air be or be not predominant in a propos'd Body, when we would know whether it will or will not sink in an assign'd Liquor.

And though we should admit the Air, whether included in the Pores, or lookt upon as an Elementary Principle to be the Cause of its being lighter than an equal bulk of Liquor, yet the Air would be but the remote Cause of its swimming, its immediate Cause being that the floating Body is lighter

lighter than an equal Bulk of the Liquor, and therefore the same Body without acquiring or loosing Air, may swim in one kind of water, and sink in another. As in the case of heavy Bodies, as Loaden Ships, that having prosperously sail'd over the Sea, are recorded to have sunk as soon as they come into Harbour, i. e. into a more fresh water; and an Egge that will sink in common water, will swim in a strong Brine. Nay a Body may (as I and others have tryed) be so pois'd in water, that if the Liquor be a little warmer then when the Body was pois'd in it, the Body will sink; as twill emerge again upon the Refrigeration of it.

And if this general Answer of the Lightnes of the Air will not give so good an account as Hydrostatical principles, why a piece of Wood will float or sink, it will much less give so satisfactory an Account, why differing Woods in the same water, or the same piece of Wood in differing waters, will sink just so far and no farther; whereas by Hydrostatical principles the *Phænomenon* is easie to be accounted for, according to that Theorem of *Archimedes*, *vel si expetitur*, That Solids lighter than the Liquor they are put into, will sink in it so far, as that as much of the Liquor as is equal in Bulk to the demersed part, be equal in weight to the whole floating Body: whence these Corollaries are deriv'd, That a floating Body has the same proportion in weight to as much Liquor as is equal to it in Bulk, as the immerl'd part of the Body has to the whole Body. And likewise, That as much Liquor as is equal in Bulk to the whole Body, has the same proportion in weight to the said Body, as the whole Body has to that part of it self which is beneath the surface of the Liquor. And as these Corollaries determine the Proportion between the immers'd and extant part of the floating Body; so (to shew you that these Theories lead to Practice) they suggest the way of making a small and light Instrument, elsewhere describ'd, to measure by a floating Body the differing Gravities of several Liquors

Lib. 1. Prop. 5.

Liquors in reference to one another, as well as to the Body it self. And upon the same Grounds the Learn'd *Stevinus* shews, That if you know what part of a floating Body is immers'd in a Liquor, whose Specifick Gravity is also known, as it easily may be, you may presently find the weight of the whole Solid Body, let it be never so much too great to be weigh'd in Ballances or Statera's, yea though it were a vast Ship it self; as supposing that that part of such a Vessel, that lies under water should be 100000 Cubick foot, and that a Cubick foot of Water weighs 70^l, (which though it be not the weight we have observ'd a Foot of Water English-measure to amount to, yet that alters not the general Rule,) by multiplying 100000 by 70 the Product will be 700000^l for the weight of the whole Ship, with all that's contain'd in it, as Ballast, Ordinance, &c. or rests or Leans upon it. If I should ask a meer School-Philosopher, why Sucking-Pumps will not raise Water higher than 40 Foot, (though it be commonly presum'd they will raise it to any height,) or why in an inverted Siphon of Glasse if you pour Water and Quick-silver in a sufficient Quantity, the Surface of the water in one Leg of the Siphon will not be in a Level with the Surface of the Quick-silver in the other, but 13 or 14 times as high above the bottom of the Siphon: or why, if a piece of Iron, and a piece of Marble or a Flint &c. be equiponderant in the Air, if the Scales be let down into the water, the Metal will appear far heavier than the Stone. If, I say, I should ask a meer Naturalist both these or the like Questions, I doubt I should much more perplex him, than he would satisfie me. And twere easie to adde a multitude of Examples, whereof a good Account will scarce be given by a Naturalist that is unacquainted with Mechanicks, and may easily be assign'd by one that is skill'd in them. But referring the Schoolmen to *Aristotle's* Mechanical Questions, to shew them the Necessity and Usefulness of Mechanical Knowledg,

to give the Solution of sundry *Phænomena* that frequently occur, I will onely adde an Example or two to make good the most Paradoxical part of what I was saying; namely, that there are divers Physico-Mechanical *Phænomena*, which are not to be, I say not explicated, but so much as well understood, without the knowledge of Mechanical Disciplines.

There is a considerable Theorem in Hydrostaticks, which is thought to have been first taken notice of by *Mersennus*, and in a late Writer is thus exprest: *Velocitates motus aque descendantis & effluentis per Tubos equalium foraminum, sed inequalium altitudinum, habent subduplicatam rationem altitudinum.* Of which the Corollary is, That the Tubes are in a duplicate *ration* to that of the velocities of the Water that subsides in, and runs out of them; so that to make one Tube at a Circular Hole of the same Diameter run out in the same time twice as much Water as another, the greater ought to be not onely twice but four times as long as the shorter. And of the same proportion (my Tryals about which I may elsewhere acquaint you with) divers other Practical Applications may be made, which must not be here insisted on.

IV. As I formerly said of the Mathematicks, so I now say of the Mechanicks, that they may assist the Naturalist to multiply Experiments by those Enquiries that they will suggest, and those Inferences and Applications whereto they may lead us.

Of this we have a noble Instance in the great variety of Tryals, which Enquirers, vers'd in Hydrostaticks and other Mechanical Disciplines, have upon the score of their being so Qualified, been either prompted, or at least assisted to make, about the famous Quicksilver-Experiment devis'd by *Torricellius*, about which though so much has been done already, yet almost every year brings forth new *Phænomena*.

Another Example to our present purpose we may take from the great Number of new Propositions that the Dilligent *Mersennus* has given us in his *Balisticks*, about the Force and Effects of Bows, and the like Springy Bodies. But a yet more noble Instance is given us by the most Ingenious *Galileo*, who, as we may learn from the already mentioned *French Writer*, that has given us an account of *Galileo's* new Thoughts in that Language, has publish'd so many Propositions (of which he sets down 19 or 20, with the Demonstrations) about the resistance of Bodies to be broken, and the Weights requisite to break them, and the Lengths at which they may be broken by their own Weight, that he has reduc'd them into the Form, and given them the Title of a new Art.

To all which I shall need to adde no more, than that he who knows and considers what a variety of Useful Propositions have been or may be Mechanically deduc'd from the Observation of *Archimedes*, That a Solid Body weighs less in Water than in the Air by the weight of Water equal in Bulk to that Body, will easily dispence with me for not adding any farther Instances on this Occasion.

And the mention of this Hydrostatical Proposition of *Archimedes* falls in the more properly in this place, because it will warrant me to tell you, that divers Mechanical Theorems are not onely fertile in other Theorems, but in useful Applications too, of which I may hereafter have Occasion to give you some Examples, by acquainting you with the Uses I have made of the lately mentioned Proposition of *Archimedes*, and some Corollaries, that partly by others, and partly by us, have been infer'd from it.

V. Besides the Utilities that may be ascrib'd to the Mechanicks in common with the more Speculative Mathematical Disciplines, they have some (as I formerly intimated) that are more peculiarly their own, since they may be of great

great Use to the Naturalist in making of such Instruments and Tools, as for many of his Observations, Tryals, and other purposes, he may either absolutely need, or advantageously imploy.

Of this we have an Example in the Mariner's Compass, as tis call'd; which is so necessary to those remote Navigations, whereto Natural Philosophy and Mankind owes so much. For though *Baptista Porta* does, as well as other Authors, ascribe the Invention of the Directive Faculty of the Magnetick Needle to one of his Countrey-men (*Amalphi*. in the Kingdom of *Naples*;) yet he confesses, that for want of the knowledg of making such Sea-Compasses as we now use, this Lucky Inventor was fain to make use of a piece of Wood or Straw, to keep the Needle a float, and then imbue it with a Magnetick vertue; which was a Shift subject to great and manifest inconveniences. And indeed, notwithstanding the knowledg of the Verticity of Magnetical Needles, if by that of the Properties of the Center of Gravity, or some Practices deriv'd thence, some men vers'd in Mechanicks had not devis'd a way so to poise the Needle, that notwithstanding the Rolling and Tossing of the Ship, it will continue Horizontal enough to direct the Pilot; what would become of him in those Storms, when he has most need of a faithful Guide?

Mag. Nat. lib.
7. cap. 32.

By the help of the Centrobarrical Doctrine Mechanicks have been enabled to make those Diping Needles, whose *Phanomena* are very odde, and though, as far as I have try'd, they yet seem uncertain enough, yet it may very possibly happen, that farther Observations may reduce them to some Theory, whence Practical Inferences may be deduc'd.

And you will the more easily believe, that the Mechanical Applications of Centrobarrical Notions may be of immediate Use, if we consider, That by virtue of them divers Writers, and others of unsuspected Credit assure us, that they

have made a kind of Lamp so pois'd, that one may role it up and down like a Bowl, without overturning the Vessel that contains the Oyl, or extinguishing the Flame.

From the knowledge that compress'd Air has a Spring, whereby it resists farther Compression, and a slight Contrivance to make Use of this Pneumatical Principle, an Acquaintance of mine made a slight Engine, which afterwards I found mention'd in a printed Book, by which he was a great Gainer, going, when he was well satisfied for his pains and hazard, to the Bottom of the Sea, and by the help of this Engine staying there sometimes for divers Hours, till he had fetcht up valuable things out of sunk Ships, and tyed Cables about their Guns, that they might afterwards be Buoy'd up.

But there might be given so many Examples of Instruments and Tools, that are useful to the Naturalist, and for which yet he ought to thank the Mechanicks, that twere tedious to enumerate them, especially since the Shops of Mathematical Instrument makers and other Tradesmen, may supply you with enough of them, to verifie what this Paragraph would perswade.

VI. I shall conclude the Considerations I design'd for this Essay by this, That as the Knowledge of the Theorems of Mechanicks, and the Practices which have been thence deriv'd, may very much assist the Naturalist to make good Mechanical Contrivances, according to the Exigences of his several Purposes; so one good Mechanical Contrivance may be equivalent to, and may perhaps actually produce, many good Experiments.

The former part of this Proposition will not, I think, require much Proof. For a man must be but a dull Naturalist, that shall know the Properties of the Center of Gravity, of Leavers, Ballances, Screws, Wedges, and other Instruments for increasing Force, and by frequenting the Shops and
Work-houses

Work-houſes of Mechanicians, ſhall have ſeen variety of Engines and Instruments to compaſs different things, if he do not from the Survey and Conſideration of all theſe, grow more able by compounding, varying, and otherwiſe improving them, to deviſe ſuch Means and Expedients, as he would not elſe have thought on, to make *ſome* Trials that he could not make before, and to make *others* more accurately, or more eaſily, or ſome way or other better.

And as to the ſecond part of our Proposition, namely, that one good Mechanical Contrivance may be as conſiderable as many particular Experiments, by enabling the Naturaliſt to produce either Numerous, or Noble ones, or both, it may be manifeſted by ſeveral Examples.

And I ſhall begin with ſo familiar a one, as That afforded by Valves, or Trap-doors. For as ſlight and obvious as the Invention of them ſeems, yet not onely we owe to them a great variety of Pumps and Bellows for Oeconomical uſes, but they make very conſiderable parts of ſeveral other Engines, and may, as ſome Trials have inform'd us, be applied about ſeveral new Experiments, eſpecially if they be made of Braſs, and yet ſo ſmall, that like ſome of thoſe I have had made by ſkilful Workmen, (who, when I firſt directed them, told me, that they could not be made,) they may be uſ'd not onely in ſmall Glaſs-pipes, but in Syringes themſelves.

By the help of ſmall Valves, and the knowledg of the Spring of compris'd Air, have been made thoſe Wind-Guns, which may be imploy'd not onely to weigh the Air, (whole Weight we found them to evince, but not determine,) but to kill Deer, and other Game, without making a great Noiſe, that would fright away the reſt.

If I did not, *Pyrophilus*, foreſee, that in the following Eſſays of this Treatiſe I ſhall have occaſion to mention ſome other Inſtances of the Service that Mathematical and Mechanical

nical Disciplines may do the Naturalist, I should here add divers particulars, which I had rather you should, when you meet with them, refer hither, and therefore I shall conclude what I intended now to say about these Disciplines, by two or three short Instances, that relate to what I have already said concerning them.

The *First* is, that 'twas not my Design to treat of the Utility of the Mathematicks and Mechanicks in an absolute way: For then I must have said much to their Advantage which I have omitted, because it would have too much swell'd these Essays, and not have been pertinent enough to them. And therefore I thought it sufficient for me to touch upon those things, on whose account these Disciplines may be made useful to the Naturalist, by assisting him either to frame Theories, or to make Observations and Experiments, some (at least) of which, directly, or in their Applications, either are already, or are like to prove, Practical and Useful. And it seems to me very probable, that the Notions and Practices of these Disciplines, that have been too much hitherto restrain'd by meer Mathematicians and Mechanicians to the Stars, the Earth, the Water, and some few other conspicuous parts of Nature, may be very well extended by a Philosopher to sundry other Productions, as well of Nature, as of Art. As *Archimedes* deduc'd Hydrostaticks from the Application he made of vulgar Staticks, to Bodies weigh'd in Air and Water, or in Water onely: and the ingenious *Toricellius*, and others, have of late apply'd the Principles of Hydrostaticks to that ponderous Body (which the Chymists reckon among Metals) Mercury.

My next Advertisement is, that mentioning Mechanical Instances, not so much to acquaint you fully with the things themselves, as to make the Medium's to infer what I would prove, I have taken the Mechanical Propositions that I employ'd, as they are delivered by the Artists themselves, with-
out

out warranting that their Proportions will hold true in Mathematical strictnes. For though I have made Tryals myself of severall things of this nature, yet having often observ'd how difficult it is to find a Mathematical *preciseness* in Physical and Mechanical things, I think it not amiss to intimate thus much to you, though I may elsewhere have a fitter opportunity to make it out, that so great an exactness is in many cases not necessary to make the Rules that want it, useful in Practice.

The Concluding Intimation I mean to give you, is, That I have not hitherto mention'd a Service, that Mathematicks and Mechanicks may often do the Naturalist, which is not fit to be silently pretermitted, and it is, That by Lineal Schemes, Pictures, and Instruments, they may much assist the Imagination to conceive many things, and thereby the Understanding to judg of them, and deduce new Contrivances from them.

That I do not groundlessly say this, you will grant, if you consider how difficult (not to say impossible) it were to go through with a long Geometrical Demonstration, without the help of a visible Scheme, to assist both the Fancy and the Memory; and how difficult it is to give Beginners an *Idea* of the Grounds of Cosmographie and Geographie, without Material Schemes and Globes, your own very recent Experience, as well as that of others, will, I presume, inform you. As it also may, how useful, not to say how necessary, Pictures, and in some cases, Models, are wont to be, when Engines, Houses, Ships, and other Structures are to be judg'd of, that they may be approv'd, or improv'd: but I shall rather take notice, that not onely Mechanical, Mathematical, and Anatomical things, need Schemes and Pictures, to represent them clearly to our Conceptions; but many things that are look'd upon as more purely Physical, may, in my Opinion, be much illustrated the same way. Of which if

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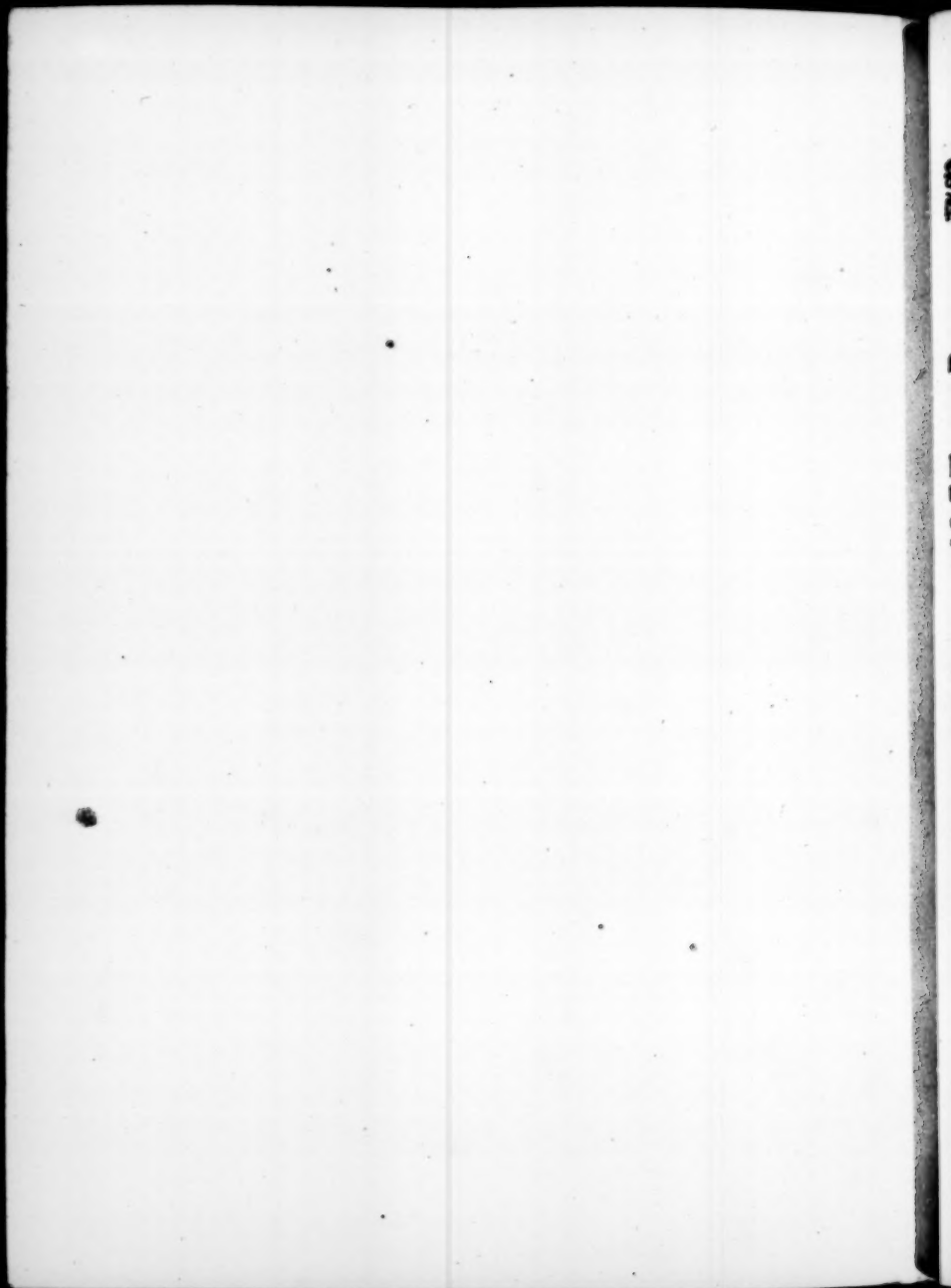
Des Cartes has, as some say, been the Introducer, I think he deserves our Thanks for it. For as *Plato* said, God does always Geometrize; so in many cases it may be as truly said, That Nature does play the Mechanician, not onely in Animals, but in Plants and their Parts, and divers other Bodies; in the Explication of which Curious, and oftentimes invisible Contrivances of Her's, Pictures, that represent them well to the Eye, and, if twere needfull, in Dimensions much greater than Natural, may very much further the framing of right *Ideas* of them in the Mind.





That the
GOODS OF MANKIND
may be much encreased
by the NATURALIST'S
Insight into *TRADES*.







*That the Goods of Mankind may be much encreased
by the Naturalist's Insight into Trades.*

TO make out what is propos'd in the Title of this Discourse, I shall endeavour to shew two things. The One, That an Insight into Trades may Improve the Naturalist's Knowledge. And the Other, That the Naturalist, as well by the skill thus obtain'd, as by the other parts of his knowledge, may be enabled to Improve Trades.

The 1. Section.

AND first, it seems to me to be none of the least prejudices, that either the haughtiness and negligence, which most men are naturally prone to, or that wherewith they may have been infected by the Superciliousness and Laziness, too frequent in Schools, have done to the Progress of Natural Philosophy, and the true Interest of Mankind, that Learned and Ingenious Men have been kept such strangers to the Shops and Practices of Tradesmen. For there are divers considerations that perswade me, that an Infection into these may not a little conduce, both to the Increase of the Naturalist's knowledge, and to the Melioration of those Mechanical Arts.

I. And, I consider in the first place, that the Phenomena afforded by Trades, are (most of them) a Part of the History of Nature, and therefore may both challenge the Naturalist's Curiosity, and add to his knowledge. Nor will it suffice to justify Learned Men in the neglect and contempt of this Part of Natural History, that the Men, from whom

2 *The Goods of Mankind may be much increased*

it must be learn'd, are illiterate Mechanicks, and the things that are exhibited are works of Art and not of Nature. For the First part of the Apologie is indeed Childish, and too unworthy of a Philosopher to be worthy of a solemn Answer. And as for the Later part, I desire, that you would consider what we elsewhere expressly Discourse against the unreasonable difference, that the generality of learned Men have seem'd to fancy betwixt all Natural things and fastitious ones. For besides that many of those Productions, that are call'd Artificiall, do differ from those, that are confessedly Natural, not in Essence, but in Efficients; there are very many things made by Tradesmen, wherein Nature appears manifestly to do the main parts of the Work: as in Maulting, Brewing, Baking, making of Raisons, Currans and other Dried Fruits; as also Hydromel, Vinegar, Lime, &c. and the Tradesman does but bring visible Bodies together after a grosse manner, and then leaves them to act one upon another, according to their respective Natures; As in making of green (or course) Glasle, the Artificer puts together Sand and Ashes, and the colliquation and union is perform'd by the action of the fire upon each Body, and by as natural a way as the same fire, when it resolves wood into Ashes, and Smoak unites Volatile Salt, Oyle, Earth and Flegme into Soot; and scarce any man will think, that when a Pear is grafted upon a white Thorne, the fruit it bears is not a Natural one, though it be produc'd by a Coalition of two Bodies of distant Natures put together by the industry of Man, and would not have been produc'd without the Manual and Artificial Operation of the Gardener.

II. But many of the Phænomena of Trades are not only parts of the History of Nature, but some of them may be reckon'd among its more noble and usefull Parts. For they shew us Nature in *motion*, and that too when she is (as it were) put out of her Course, by the strength or skill of Man

Man, which I have formerly noted to be the most instructive condition, wherein we can behold her. And as 'tis manifest that these Observations tend directly to Practice, so, if I mistake not, they may afford a great deal of light to divers Theories, especially by affording instances, wherein we see by what means things may be effected by Art, and consequently by Nature that works Mechanically.

III. The Phænomena afforded by Trades are therefore the fitter to be translated into the History of Nature by Philosophers, because they, whose profession 'tis to manage those things, being generally but Shop-keepers, and their servants being for the most part but Apprentices and Boyes, they neither of them know themselves how to describe in writing their own Practices, and record the Accidents they meet with: so that either Learned men must observe and Register these things, or we must, to the no small Prejudice of Philosophy, suffer the History of Nature to want so considerable an Accession, as the Shops and Work-houses of Crafts-men might afford it; which accession would be much the more copious, if the Experiment of Trades were made by a Naturalist, who would doubtless so manage them, as to make them farr more Instructive and better fitted for the designe of a Natural History, than the same Experiment would be, if they were related but by an illiterate Tradesman, though never so honest.

And, *Pyrophilus*, to invite you, as you designe a further Progress in Natural Philosophy, to disdain as little as I do, to converse with Tradesmen in their Work-houses and Shops; give me leave to tell you, that as he deserves not the knowledge of Nature, that scornes to converse even with mean Persons, that have the opportunity to be very conversant with Her; so oftentimes from those, that have neither fine Language nor fine cloaths to amuse him with, the Naturalist may obtain informations, that may be very

4 *The Goods of Mankind may be much encreased*

usefull to his design, and that upon several scores.

For first, Tradesmen are usually more diligent about the particular things they handle, than other Experimenters are wont to be; because these, if they want diligence, loose nothing, but what that very want of it keeps them from taking notice of, or at most the satisfaction of an unnecessary curiosity; whereas Tradesmen have another ghesse concern in the management of what they employ themselves about, for their livelyhood depends upon it. And *as*, if they be careless, others more diligent will get away their Custom; *so*, if they do any thing extraordinarily well, the chiefeft and for some time, the whole Benefit will accrew to themselves, and by improving their Profession they better their Income.

Secondly, As it is Proverbially said, that Necessity is the mother of Invention, so Experience daily shews, that the want of a Subsistence, or of Tools and Accommodations, makes Craftsmen very Industrious and inventive, and puts them upon employing such things to serve their present turnes, as nothing but necessity would have made even a knowing man to have thought on. By which means, they discover new uses and Applications of things, and consequently new Attributes of them; which are not wont to be taken notice of by others, and some of which, I confess, I have not look'd upon without wonder.

Thirdly, I have severall times observ'd Trades deal with things unknown to Classical writers, and unus'd, save in their Shops. And these are not only factitious, but divers of them Natural; as Manganese (by some call'd Magnesca;) & Zafra (if at least it be what many repute it) Emery, Tripoli, &c. and of both sorts there are some, that are exceeding usefull; as of those formerly mention'd, the two first are to Glasse-men and Potters; and the two Later to a number of other Tradesmen; and as among Artificial

Concretes,

Concretes, Soaders are of necessary use to Gold-smiths, Lock-smiths, Copper-smiths, Brasiers, Pewterers, Tin-men, Glasiers, &c. Amels to Gold-smiths, Glas-men, &c. Lakes of several sorts to Painters, Heraulds, &c. and Putty to Amel founders, Potters, Stone-cutters, Gold-smiths, Glas-grinders, and divers other Professions. I shall adde, that ev'n of those natural things, of which some mention is made in famous Books, one may learn many things in Shops, not to be met with there, both as to the differing kinds of things, and as to the marks of their goodness, and as to other Particulars conducive to the knowledge of those subjects. And I freely confels to you, *Pyrophilus*, that I learn'd more of the Kinds, Distinctions, Properties, and consequently of the Nature of Stones, by conversing with two or three Masons, and Stone-cutters, than ever I did from *Pliny* or *Aristotle*, and his Commentators.

Fourthly, You shall often find, that Trades-men, being unacquainted with Books, & with the Theories & Opinions of the Schools, examine the Goodness & other Qualities of the things they deal with, by Mechanical waies, which their own sagacity or casual Experiments made them light upon. And though these, having litle or no affinity with those that a Book-man would have taught them, will appear to him extravagant; yet being such, as, if they really serve the Crafts-man's turn, must be true and useful, their being extravagant will but make them the more new and Instru-ctive, and consequently the more fit to be admitted into the History of Nature.

Fifthly, The Observations that Trades-men can supply us with, though they are not probably at any one time so accurately made by them, as they would be by a Learned man; yet that defect is recompensed by their being more frequently repeated, and more assiduoussly made, than most of the Experiments wherewith men of Letters have furnished

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furnished Natural History: so that those Circumstances, which are not heeded by the Artificer at one time, may obtrude upon his observation at another, and by reiterating the same Processes so often, it can scarce be doubted, but that divers Phænomena will offer themselves, even to an unattentive Eye; that would not have been all of them taken notice of by a more heedful Experimenter, that had perform'd the Operation but once or twice. But this will be further confirm'd in the next Paragraph.

Sixthly, There are Tradesmen, that do often observe in the things they deal about, divers Circumstances unobserved by others, both relating to the Nature of the things they manage, and to the Operations performable upon them.

Of the particulars, wherein the Observations of Tradesmen (for the Utility of many of their Practises is not questioned) may help us to investigate the Nature of Bodies, I could name more than my present haste allows me to mention, and I shall, as a Specimen, take a little notice, first, of some of the Remarks they have to distinguish and estimate what they call the *Goodness* and *Badness* of the things they deal with; and then of some few of their Observations, that depend upon the Influence, that Time and Season have on the Things they handle, and upon the Artificers Operations on them. For (to begin with the first) although they commonly mean by such termes (of *Goodness* and *Badness*) no more, than the *fitness*, or *unfitness* of such things to yeild a good price, and in order thereunto for the purposes they are to be employed about in their particular Trades; yet this *fitness* or *unfitness* is wont to consist in, or to suppose, Qualities, that may relate to divers other things, and be apply'd to many other purposes. For some of the Tradesmen's Criteria discover to us a variety and a difference of kinds in Bodies of the same Denomination;

tion; as from the Potters, the Tobacco-pipe-makers, and the Glassemen, we may learn a considerable variety of Clays; and from Stone-cutters and Masons no lesse variety of Stones untak'n notice of by Classick Authours. So from Carpenters, Joyners, and Turners we may learn, that some woods, as Oake, are fit to endure both wet and dry weather; others will endure well within doores, but not expos'd to the weather; others will hold out well above ground, but not under water; and others on the contrary will last better under water, than in the Aire.

And as the Distinguiſhing markes we were speaking of may informe us of the differences and kinds of Bodies; so they may likewise on other Accounts give us notice of divers of their Qualities. Thus we find by the Glasſe-men and Soape Boylers, that some Ashes, as those of Kely, Bean-stalks &c. do much more abound in Salt, than other some; and yet some of those sorts of Ashes make cleerer, or otherwise better glasſe, than the rest do. We may likewise learne of the Maulsters the differing Impressions, that the Barly receives according to the fewel, whether Straw, Wood, Furs, &c. that makes the Fire wherewith 'tis dry'd. And I remember, I have known an-Ingenious Maulster much advantag'd by a way he had of so preparing Mault, as if it had not been dry'd with Wood, (usually the cheapest, but not the best, fewel for that purpose) whereas indeed it was a Secret consisting onely in the choice and seasoning of such a kind of Wood, that ev'n the solid parts of it cleft, burnt almost like straw with a cleer flame, so strangely free from Smoake, that I could not behold it without some wonder.

The other sort of Instructive observations to be learn'd of Tradesmen consists of those, that are made about the Operation, that continuance of time, or change of season and weather, may have upon certain Bodies, and wayes of han-

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dling them. For naturalists, usually contenting themselves to make their Experiments but once or twice, when their leisure best serves, or their occasions most require, have not the same opportunity to discern what influence the temper, which the Aire then is put into, either by the season or the weather or both, may have on the Event of the Tryall; whereas Tradesmen, by long and sometimes unwelcome Experience, are taught such and such things will be best done at such seasons of the year, or in such kind of weather, which if they be not in some cases observ'd, either the thing will not succeed, or the Trades-man will be damnify'd by his Tryal.

Thus we see, that Tanners make choice of that part of the spring, when the Bark abounds with the rising sapp, to take it off from the Trees; because at all seasons it will not be so good nor come off so easily. Thus Joyners think not Wains-coat sufficiently season'd till it be so many years old, And in several Countrys, Butchers observe, that though a young Bullock may be very good meat, if spent soon after 'tis kill'd, yet if powder'd, to be long kept, before the beast be 4 or 5 year old, the salt will too much fret it, and make it little worth. And I look upon it as one of the Advantages the Naturalist may derive from Trades-mens Observations; That the same things being successively dealt with by the Father and the Son, the Master and the Apprentice, they sometimes make farre more long winded Observations, than the Philosopher has opportunity to do. As, for instance, those that make Mortars of *Lignum vita*, and will make them good, will keep it in the house 20 years, or perhaps more, to season (as they call it) before they will Employ it. And Experienc'd Masons tell us (and as farre as I have observ'd truly enough) that as there are some sorts of Lime and Stone, that will decay in few years; so there are others, that will not attaine their full hardnesse in 30 or 40, or a much longer

longer time. Of which I may elſewhere give you ſome Inſtances.

To the ſix foregoing particulars, one more may be added to the ſame purpoſe with the reſt, and it is; That by frequenting the worke-houſes and ſhops of Crafts-men, a Naturaliſt may often learn other things, beſides the truth and falſity of what they relate, concerning the Hiſtory of the Arts they make Profeſſion of. For though a Trades-man, being for the moſt part unlearned and aiming onely at making or performing thoſe Particular things, which when done, are to bring profit, uſually overlooke thoſe Phænomena, that make not to his Purpoſe; yet Nature, (who minds as little his Deſigne, as he do's thoſe works of Hers, that conduce not to it) is by ſome Agents and Operations, that he employs to compaſſe his Ends, engag'd to do ſeverall things that have a connection which thoſe the Artiſicer Proſecutes, or elſe doe depend upon them: ſo that the Naturaliſt may oftentimes obſerve in Shops divers conſiderable Phænomena, that the Trades-man regards not; becauſe they neither further, nor hinder him in his work, and will be look'd upon by him as impertinent to the Hiſtory of his Profeſſion, in caſe he ſhould be put upon delivering it. And yet ſome of theſe occurring Phænomena being produc'd by nature, when ſhe is as 'twere vex'd by Art, and roughly handled by ways unuſual, and ſometimes extravagant enough, may diſcover to a heedful and rational man, divers Luciferous things not to be met with in Books, or probably not ſo much as dreamt of by the Authors of them. Sundry Examples of this I ſhall have occaſion to diſperſe in the following Eſſay and other Tracts, that are deſign'd you in this Second Volume of our preſent Treatiſe.

The II. SECTION.

I Will now therefore proceed to shew, that as the Naturalist may (as we have seen) derive much knowledge from an Inspection into Trades; so by virtue of the knowledge thus acquir'd, as well as by that, which he has upon other Accounts, he may be able to contribute to the Improvement of Trades.

This he may do by several wayes, and especially by these Three. The first, by increasing the number of Trades, by the addition of new ones. The second by uniting the Observations and Practises of differing Trades into one Body of Collections. And the third by suggesting improvements in some kind or other of the Particular Trades.

The first of these I shall here lightly passe over, having elsewhere Occasion to discourse of it more fully; only I shall here take notice, that, For the Experimental Philosopher to increase the number of Trades now in use among us, it will not be absolutely necessary, that he should invent new ones, since he may do it by reviving the Trades formerly known to the Antients, but lost to us: such as the making incombustible Cloath of Lapis Amiantus, the Tyrian Purple, the Making of Mosaick work, and those many other Inventions which you may find mention'd in *Pancirollus*, and his Learned Commentator *Salmuth*. Of which it were not amiss that a Catalogue were made publick; for such things, having been once actually done by men, are not impossible to be done again, and therefore I see no Reason to despair, that in so Ingenious an Age as this, some, if not most, of them may be retri'd.

The second Advantage, that Trades may derive from an Inquisitive Naturalist, is; That by this means the severall Observations and different practices of Trades, whole managers

managers want the Curiosity, the skill, or the Opportunity, to make a general Inspection into Trades, which they would find the more difficult to do, because Crafts-men will often be more shie of one another, and more backward to disclose the mysteries of their art to one, that may make a gain of it (and thereby lessen theirs,) than to a Philosopher, that Inquires to satisfy his Curiosity, or Enable himself to be helpful to them. And certainly, if so much as the known hints, that may be given by the Experiments already dispers'd among men of several Professions were known to any one man, though otherwayes but of common abilities; (as my own Experience has in some measure inform'd me) those united Beams, which scatter'd are scarce considerable, would afford him light enough to better most of the Particular Trades, that are Retainers to Philosophy. And perhaps, it were not amisse, if there were some knowing & Experimental Persons appointed by the publick to take an exact survey of the Trades in use amongst us, & informe themselves particularly of all the Secrets & Practices belonging to them, that thus discerning the Errors and Deficiencies of each, they may rectifie the one, and supply the other, partly by the hints afforded by the analogous Experiments of some other Trades, and partly by their own notions and Tryals.

Thus a few of the more Ingenious French Gardeners have of late usefully apply'd, to the watering of young and tender Plants, that way of filtration, which is us'd by Apothecaries with moistn'd Cotton weeks or Rouls, or else with lists of either Linnen or Woollen Cloath, so order'd, that one end being immers'd in the Liquor to be strain'd, the other may hang over the Brimme, and out of the vessel somewhat lower, than the Bottom (or at least the surface) of the Liquor. For if this Lower end of the List be plac'd over the Root of any seed or tender Plant, it will, by constantly & leisurely dropping on it, water it much more temperately and uniformly,

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formly, than can be done by common watering Potts. And ev'n this way of Irrigation may by a cheap and easy mechanical contrivance be very much improv'd. There is another Practice among Stone Cutters, that cast or mold things with Plaister of Paris, to obtain finer Powders, than Searces are wont to give them, by stirring the Powder well in water, and after it has rested a little while, pouring off the upper part of the troubled Liquor into another clean vessel; at the Bottom of which there will in time settle an Impalpable Powder. I will not here tell you what use I make of this in Chymistry, to obtain much finer Powders than are usually to be met with of the same Denomination. And I shall but intimate to you, that by letting the first water stand but so much the longer before you pour off the upper part of it, 'till not only the grosser and heavier, but the lesse fine particles be subsided, you may get a Powder, yet much more subtle, than those Artificers, that imploy the former way, without this Circumstance, are wont to obtain. This, I say, it shall suffice me to have pointed at, because 'tis more proper to take notice, that the way of obtaining subtle Powders by the help of water is useful, not onely to the above mention'd Craftsmen, but likewise to Glassemen, Potters, makers of Telescopes and Microscopes, those that cast metalls in Spand, and other Tradesmen too. Besides that I may hereafter have occasion to tell you, that 'tis of great Use in China for the makers of Porcellain.

But 'tis not only by acquainting Artificers of different Professions, with one anothers practices, that the Naturalist may further Trades, but by making Materials imploy'd by one sort of Crafts-men serviceable to another. That Philosopher, who has survey'd a great number of Trades, and compar'd them together, may do this with advantage, you will easily grant, when I shall have advertis'd you, that without any such assistance as that of a Philosopher, in whom their distinct

ſtinct knowledg may concenter, and who has ſkill to enlarge the Applications of them, we may obſerve that ſometimes Trades-men themſelves can make uſe of one anothers Productions. Of which I ſhall give you a couple of Examples, the one furniſh'd me by Lytharge, the other by Aqua Fortis.

The former of theſe, which is but Lead powderd and almoſt vitrify'd, by being blown off (or melted into) the Refiners Teſt, as it ſerves the Chymiſt to make his Sugar of Lead (which it has been obſerv'd to do better, than Mini-um) and other Saturnine Medicines; ſo it ſerves divers Comb-makers to die Hornes (as we have try'd by the mixture of Lytharge, Quicklime, and ſharp Vineger. It ſerves alſo ſome Painters and others to accelerate the preparations of their fat-Oyles, as they call them. And ſome Varniſhers to make their Varniſhes dry quickly. It likewiſe ſerves ſome Artiſts to make counterfeit Gemms, and we have try'd, that by melting it with about a third part of pure white Sand, or calcin'd Chryſtalls, and then putting in a ſmall quantity of Mineral Concret's, according to the colour intended to be introduc'd, one may make Sapphyres, Emeraulds &c. colour'd like the Naturall ones, though this way makes theſe productions too ponderous, ſoft, and dimme, and is far inferiour to another we may elſewhere have occaſion to diſcloſe.

Other Mechanicall uſes of Lytharge I omit, to come to the ſecond Inſtance I was mentioning, which is taken from Aqua Fortis. For not only Refiners uſe it to part Silver from Gold and Copper (whence the *French* call it *Eau de depart*) but divers makers of curious wooden works uſe it for the diſcolouring and ſtaining of their woods. Dyers make great uſe of it about their Colours, and ev'n about Scarlet it ſelf. Other Artiſicers imploy it to colour Bone or Ivory, ſteep'd for a convenient ſpace of time therein, having firſt made it of the colour they deſire, by diſſolving in it
Copper

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Copper (instead of which I have sometimes us'd Verdigrease) or other Bodys, fit for their present turn; and some too by dissolving in it the fourth part of its weight of Sal Armoniac, turn it into Aqua Regia, and in *that* make a Solution of Gold, wherewith may be stain'd (as we have try'd and taught some Artificers) the Ivory hafts of Knives, and Boxes of the same matter, with a fine kind of purple colour, which yet will not suddenly disclose it self on them. Some Book-binders also imploy Aspertions of Aqua Fortis to stain the Leather, that makes those fine Covers of Books, that, for their resemblance to speckld Marble, are wont to be call'd Marbled. 'Tis also imployd (as themselves have acknowledged to me) by some of the Diamond Cutters, to free the dust of Diamonds from Metalline Powders, as I shall hereafter declare. 'Tis likewise of great (and as they imagine of necessary) use to those that Etch Plates of Copper or of Brasse. To which may be added, that we have caul'd Canes to be stain'd into the likenesse almost of Tortois-shell by a mixture of Aqua Fortis, not too well rectifyd (which is unexpedient in this work) and Oyl of Vitrioll lay'd on at several times and places, upon Canes, held over a large chafing-dish of Coales, that by the heat the staining Liquor may be the better suck'd in by the Canes, which must afterwards have a Glosse giv'n them, by being diligently rub'd with a little soft wax and a dry Cloth. Nor are these all the Uses made of Aqua Fortis, as you will find hereafter by Instances, that I reserve for other places. But I thought fit to mention this Liquor in this place, rather than any of those many factitious Bodys I might have taken notice of, for these *two* particular Reasons. The one, that the uses, hitherto enumerated of this Menstruum, may serve to confirm what I told you in the second Essay, of the great Utility of Menstruums. And the other, That though Aqua Fortis be a Liquor of exceeding common use, and wont to be di-

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skill'd by men of several Professions, as Chymists, Refiners, Goldsmith's &c. Yet they have had hitherto so little curiosity to enquire into the Nature of it, or vary the wayes of making it, that not onely the wayes, that a skilful Naturalist might direct for improving it, have not been taken notice of, but no small oversights may be observ'd to be generally and dayly made about it. And an ingenious Gentleman of my acquaintance, by making some Tryals to improve it, has bin so far successfull in his attempts, that he makes it by great odds better, than that which the Refiners are wont to imploy, or (as farre as my Tryals have inform'd me) than any I have us'd; and affords it for not much above half the price, that is commonly giv'n for it. Nor have his Experiments this way alone promoted the Refiners Trade, but have also disclos'd to him a way of cleerly recovering most of his Aqua Fortis, after he has us'd it in the separation of Metalls, not only in its former strength, but somewhat encreas'd in Virtue; which you will the more easily think possible, if I tell you, that Aqua Fortis may be made and receiv'd in other Vessels, than those that are usual. As also, that without dreaming of this Chymists way, I have reobtain'd that Menstruum exceeding strong, after haveing imployd it upon certain Mineralls (for from others I know not whether it may be so regain'd.) And lastly, that there are some Bodies, besides Glasse and Earth, that are not brittle like these, and yet serve for the second Destillation of Aqua Fortis, though made very strong at the first.

And since I am mentioning of this Liquor, I shall intimate (and onely intimate here) that, by adding to Salt-Peter instead of the usual Additament of three times its weight of Brick, or Clay, or the like, about an 8th or 10th part only of its weight of another substance, we have, ev'n in ordinary Sand Furnaces, obtain'd, though slowly, a Nitrous Spirit, or Aqua Fortis much stronger at the first destillation, than

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that which is wont to be sold by our Refiners, for double or rectify'd Aqua Fortis.

You, *Pyrophilus*, and divers other *Virtuosi*, have much more opportunity to make an inspection into particular Trades, than my other Studyes and Occasions will allow me, and yet I have bin more than once able to suggest to eminent Artificers such things, concerning their own Profession, as they try'd and thank'd me for. And therefore I have often wish'd, that some ingenious Friends to Experimental Philosophy would take the paines to enquire into the Mysteries, and other practices of Trades, and give us an account, some of one Trade, and some of another, though the more are handled by the same Person 'twill be *ceteris paribus* the better, not only delivering Historically what is practis'd, but also adding their own Reflections, and any other thing they think fit to propose, towards the melioration of the Professions they write of.

And to give you, for a *specimen* of this (not perhaps the best that I could, but) such an one, as will be sure not to make you despair of our doing it, I will adde at the close of this E S S A Y, what came into my mind, and cost me about an houre to set down about the Trade of those that sell Varnished wares.

Some *Italian* Writers (who indeed are to be commended for it) have given us accounts of some particular Professions, as beside others, that I have heard of, but could not procure, *Antonio Neri* has written *Dell' Arte Vetraria*, and *Benvvenuto Cellini* of *Sculpture* & the Statuaries Art, and of some other Professions, worthy, with the Art of Glasse-making, to be made English.

And indeed, I would willingly invite both you and other *Virtuosi* of our own Countrey, as well as of others, not to disdain to contribute their Observations to the History of Trades. And if you pitch upon any, you may command my thoughts

thoughts of the method wherein an account of it may be the most conveniently giv'n. For I look upon a good History of Trades, as one of the best means to give Experimentall Learning both growth and fertility, and like to prove to Natural Philosophy, what a rich Compost is to Trees, which it mightily helps, both to grow faire and strong, and to bear much fruit.

And this I was so perswaded of, that I once design'd, if the Publique Calamities of my Country had not hinder'd, to bind several ingenious Lads Prentices to several Trades, that I might the better by their meanes, both have such Observations made, as I should direct, and receive the better Historiall accounts of their Professions, when they should be Masters of them.

III. But 'tis not only by making the Practices and Productions of some Trades serviceable to others that the Experimental Philosopher may be a Benefactor to those Professions. For he may do it by the third of the formerly mention'd way's (which in some cases is coincident with the second) Namely, first by surveying the Rules and Observations already receiv'd, and the Practices already in use of each particular Trade, he would improve, and then by taking notice of two things concerning it, *viz.* the Deficiencies and Inconveniencies that blemish it, and the Optatives that may be made about it; that he may also in the last place propose Rational (if not certain) Methods or Expedients to supply or remedy the first; and either accomplish the second, or make Approximations to it, as far as 'tis feaseable, or as his skill reaches.

By Deficiencies and Inconveniencies, I do not here mean those things, which are wanting to the absolute perfection, which a Philosopher might wish to find in the Trade he considers; (for these belong to the Optatives) but those,

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which are wont to be complained of, and not irremediable; or that are wanting to a more easily obtainable degree of Perfection. I shall not pretend to enumerate these in particular Trades, but only observe in general, that the chiefest of them seem to be such as these.

First, that the Artificer may be too much confin'd to certain Materialls, some of which may be scarce, or dear, or ill condition'd, in comparison of others, that the Naturalist might propose. As I remember, that being in a place where we could not procure good Vitriol to make Aqua Fortis with, after the manner of our *English* Refiners, by a substitution of burnt Allom for Vitriol, but in a farre lesse proportion, we made Solvents for Silver, as good as theirs, if not much better.

And especially in such cases as these 'tis that the Naturalist may be very much assistant to Trades-men. For there are many things which he, who is acquainted with variety of Bodies, and the accounts on which they work on one another, will either quickly discern to be performable by other Materials, than those that Trades-men confine themselves to, or probably ghesse'd to be performable by other Agents more in the Trades-mens power, and by making Tryals of his Conjectures, 'tis like he will within a few Tryals discover what he seeks. I know an ingenious Person, that upon the general complaint made by Tanners, of the scarcity and dearness of the Bark of Oak, found a way to prepare Leather without *that* or any other Bark, as well, if not much better, than 'tis wont to be done the ordinary way, at least as far as I, and divers other more skilful than I, could ghesse by some variety of it, which he shew'd me. And this variety of Materialls, which may be suggested by the Naturalist, is therefore the more considerable, because that though the suggested Materialls be dearer, than that in common use, yet it may be so much better condition'd in other regards,

as to be preferable to it. And though Diamond Dust be very many times dearer, than the Powder of Emry, yet I sometimes cause work to be done for me in a Shop, where to cut some Gemms, and ev'n Loadstones themselves, the Crafts-men I made use of did by my encouragement employ the pretious Powder of Diamonds, instead of that of Emry, because the former makes so great a dispatch, and obliges them so much the seldomer, to change their Tools they apply it with, as makes an advantageous amends for the deerness. And so, though common Spelter-soder be much cheaper, than that which is made with Silver instead of Spelter, yet in divers cases, this last is preferable even by Artificers themselves. For tryall informs us, that this will run with so moderate a heat, as often needs not endanger the melting of thin and delicate Peeces of work, that are to be soder'd; and if this Silver soder be so well made, as some I can shew, you may with it Soder ev'n upon Soder it self made the ordinary way, with Brasse and Spelter, and so fill up those little hoales or! Cranys that may have bin left or made in the first Sodering, and are not safely to be mended, but by a Soder more easily fusible, than the first.

Secondly, that the Trades-man may be confin'd to certain way's of working, when perhaps it would be much more advantageous to him, if he had others propos'd him by the Experimental Philosopher, who may perhaps discern, that what is Mechanically done by the Artificer, may be better done Physically, and on the contrary. Whereas Goldsmiths, first directed probably by some Chymist, by boyling Silver Spurs, Hilts, &c. of curious Workmanship in Salt, Allome, and Argol, give it that whitenesse and cleannesse, which it would scarcely be securely brought to by brushing, or Pumice-stone, or Putty. And the like Cleannesse, Experience has inform'd us, that old sullyed pieces of good Gold may be brought to in a trice, by the help

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of warm Aqua Fortis. And as there are divers other things (some of which you will find mentioned in a following ESSAY) that, though wont to be done Mechanically, may be done better by Physical means; so of those things, that ought to be done Mechanically, many things that are wont to be done by the labour of the Hand, may with far more ease and Expedition (the quantity considered) be performed by Engines; by which, if they be skilfully devised, our Observations make us bold to think, That many more of those, that are wont to require a laborious or skilfull Application of the hands, may be effected, than either Shopmen or Book men seem to have imagined. For not to mention those severall Instruments on which I have *extempore* played divers Tunes, that I had never learned, when we see that Timber is sawd by Wind-mills and Files cut by slight Instruments; and even Silk-stockings woven by an Engine, besides divers other Artificial Inventions left not nam'd, because they cannot intelligibly be so in few words, we may be tempted to ask, what handy work it is, that Mechanicall contrivances may not enable men to performe by Engines.

Thirdly, there may be deficiencies also in this, That what the Artificer undertakes, is either long in doing (as in the ordinary way of Tanning, Brickmaking, seasoning Wood &c.) or takes up more paines, or requires a greater Apparatus of Instruments, or else is some other way more chargeable, or troublesome, or laborious to be effected, than it needs be. And these kinds of Deficiencies may in very many cases be supplyd by the Experimental Philosopher. As I know an Inquisitive Person, that has, upon a solemn Tryall, tanned as well as the Masters of the Profession, in far lesse time, (and if I much forget not, in lesse by above half) than they; so in some places they have a quick way of seasoning some kinds of Wood, for the use of Sea-Timber,

ber, by baking it in Ovens, (which way I have alſo known uſed here in *England* to ſeaſon ſome ſorts of Wood for other uſes in a few Howres) ſo whereas our Grinders of Dioptrickall Glaſſes have hitherto beleived, that they muſt make uſe of Venice Glaſs, which is very deer and oftentimes very ſcarce to be come by, ſome *Virtuoſi*, conſidering, that the great cleerneſſe of an Object Glaſs is rather an Inconvenience, than a very deſirable Qualification, have newly taught ſome of the Artificers to imploy that courſer and cheaper ſort of Glaſſe, they call Green-Glaſſe, which is made here in *England*, inſtead of the other, which now begins to be thought by the ſkilful (with whom my Obſervations diſagree not) to be inferior to it. And ſeveral Dyers imploy our Woad, which is not far fetched and much cheaper, inſtead of the Eſtern Indigo for Dying of ſome, (if not all) ſorts of Blews, and thoſe other colours, which that Grand Tincture prepares the Cloath to receive.

Fourthly, another ſort of Deficiencies or Inconveniencies may be the want of Durableneſſe, either, as to the very being of the thing produc'd by the Artificer, or, as to the Beauty or the goodneſſe of it.

Of the former ſort may be (not to mention the Decay and ſowring of Cyder, Perry, &c.) the Cracking of Glaſſe of its own accord, and particularly that, which is complained of by divers, who deale in Telescopes, That the Object Glaſſes, which are wont to be made, as I was ſaying, of fine Venice Glaſſe, will ſometimes, (eſpecially in the Winter) ſlaw of themſelves, and ſo grow uſeleſs, to prevent which, ſome, that are very curious, carry them in their pockets.

Of the latter ſort, is the fading of the Bowdie and of Water Colours in Limning, and the Ruſt of ſhining Arms, and other poliſhed Steel. Divers of theſe Inconveniencies alſo the Naturaliſt may obviate or remedy, As ſome of the *Virtuoſi* above mentioned, by teaching the Glaſs-Grinders to
make

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make the Object Glasses of their Telescopes of Green-Glasse, have taught them a way to make them durable in spight of the vicissitudes of weather. And I have had pieces of Artificiall Chrystall, whereof some, though in no long time, crackd in so many places, that they changed their transparency for whitenesse; yet another, though much larger, did, as I conjectured it would, hold sound during some Winters, nor was ever broken, but by Accident: and I remember, I told the Arcificer in whose Furnace, the Chrystal, that lasted not, had bin made, that I took, as I do still, the reason of the difference to be, that the durable Chrystal had but a due, and the other an over great proportion of fixt Salt. The reasons of which conjecture I shall have occasion to give you in another place.

And as to the Scarlet Dye (whereof I lately made mention) that it may be much advanc'd, as to point of fixtnesse and lastingnesse, beyond the common Bowdye, I was persuaded by an honest merchant of *Amsterdam*, who had got a great Estate by colouring of Cloth, and was particularly curious about the Scarlet dye. For he presented me with a piece of Scarlet (of which he said he could make enough at a reasonable rate, wherein he almost defy'd me to finde either any part undy'd, or to stain it with Viniger, Lixivium and other Liquors, that he nam'd, and indeed by cutting it I found, that though it were a thick peece of Cloth, the middle of it was not (as is usuall in Scarlets) white or pale, but it was dy'd quite thorough; and though of Scarlet I shall elsewhere have occasion to speak farther, yet I ther rather mention it in this place; becaule it affords me a notable instance, that Trades may be considerably improv'd by those, that do not profess them. For the most famous *Cornelius Drebel*, who was the Inventor of the true Scarlet dye, was a Mechanicien, and a Chymist, not a Dyer; and as an ingenious man, that marry'd his Daughter, related to

me,

me, was so far from having bin vers'd in that Profession, when some Merchants put him upon the Advancement of a certain way of dying a fine red, or rather Crimson, that had bin a while before casually lighted on in *Holland*, and prov'd very gainful to the Finders, that he did not know so much as the common way of Dying the ordinary Reds, though the Merchants having once taught him that, by the help of a sagacious Conjecture (to be told you in one of the following Essays) he soon invented the true skarlet dye, which has since bin so much esteemed.

It now remaines, that I mention in a few words the Optatives, that may be propos'd by the Naturalist about the particular Trades he would improve. By which name of Optatives, I mean all those Perfections, that being desirable, are rather very difficult, than absolutely impossible, to be obtain'd. Of which Optatives, there may sometimes belong several to one Craft or Profession.

Of this sort in the Black-Smiths Profession may be the making Iron to be fusible, with a gentle hear (as the flame of a Candle) and yet hard enough for many ordinary uses. In the Glasse-mens Trade, and the Looking-Glasse-makers, may be the making of Glasse malleable or flexible. In the Clock makers Trade, the making the newly devis'd Pendulum Clocks, useful in Coaches, Boates, Ships, and in other cases where they are put into irregular motions.

In the Brasier and Copper-smiths Trade, the making of malleable soder. In the Shipwrights Art, the making of Boats and other Vessels to go under water. In the Diver's Profession some small and manageable Instruments to procure constantly, at the bottome of the Sea, fresh aire not only for Respiration, as long as one pleases, but also for the burning of Lights.

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In the Say-Masters Trade, the quick melting down of Oares & cupelling of them, or at least of Metalls, in a trice without Bellows or Furnace.

In the Carvers & Joyners Trade, the way of giving a shape to wood in Molds, as we do to Plaister of Paris and burnt Alabaſter.

I know, *Pyrophilus*, that ſuch Optatives may be thought but a civill name for Chymical Projects; but I ſhall hereafter more fully declare to you, why I think it not altogether unuſeful, that ſuch Optatives ſhould be propos'd, provided, as I hinted above, that they be very difficult, & not impoſſible: That is, that they be ſuch, as are not repugnant to the nature of the things, nor the general Principles of Reaſon and Philoſophie, and ſeem no otherwiſe to be Chymically or Mechanically impoſſible, than becauſe we want Toolles or other Inſtruments and wayes to perform ſome things neceſſary to the compaſſing of the propos'd End, or to remove ſome difficulties, or remedy ſome Inconveniencies, that are incident to us in the Proſecution of ſuch difficult deſigns.

And let me here tell you, *Pyrophilus*, that this Advantage may be deriv'd from the deviſeing of ſuch Optatives to bold and ſagacious Men, that if they deſpair of attaining to the Perfection they are invited to aime at, they may at leaſt endeavour to reach ſome Approximation to it: Thus unſuſpected Eyewitneſſes have inform'd us, that in ſome Countries, they are wont to ſhoe Horſes without the help of a forge, bringing their Iron to ſuch a temper, that, having a company of Shoes ready made, they can eaſily hammer them cold, ſo as to fit them to the ſize of any Horſes foot, which the heat of the Climate, where this is us'd, makes the greater Conveniency. Nor do I
much

much doubt, but that by various Tempers, Iron may be made very soft and afterward harden'd; and the rather, because, as I elsewhere tell you, we have, without Antimony or Sulphur, melted it in a Crucible, so as to pour it out like Lead, and yet afterwards it grew harder, than it was at first. So that, flexible Looking Glasses may be made with the help of *selenitis*, you will elsewhere be shewn: As also to foliate with ease all kinds of hollow Glasses, and so turn them into specula. That malleable Soder may be made, though we have not yet perform'd it, we do not much despair, and by good Silver Soder some Approximation to it has bin already made.

Submarine Navigation, at least for a short space, has bin successfefully attempted by the excellent *Cornelius Drebell*, as *Mersennus* assures us, and as I have bin inform'd, both by *Drebels* son-in-Law, and by other judicious Persons, that have had the account of the Tryals from the very men, that went in the Vessel under water for a good while together; who affirm'd, that though there were many in the Boat, yet they breath'd very freely, and complain'd not of any inconvenience for want of fresh aire. And here also give me leave to take notice, that this Inventive *Drebell* was no profess'd shipwright, nor so much as bred a Seaman.

As for the Optative propos'd for the Divers, I know one of them, who by a slight Instrument that is all under water, and has not as others, any Chimney open to the aire above the surface of the water, has bin able to stay divers houres at the bottome of the Sea, and remove his Respiratory Engine (if I may so call it) with him; and *Mersennus* assures us that a much better way, and in my opinion an admirable one, (if the thing be certain) was found out and practis'd in his Country, by one *Bariens* who was able to stay six houres under water, by the help of an al-

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most incredibly scant proportion of air, and ev'n to preserve, at the bottome of the Sea, the flame of a Lamp or Candle, in a Vessel not much bigger, than an ordinary Lanthorne.

As to the Optrative propos'd in the Say-masters Trade, I shall in the next Essay teach you a way of Cupelling in small Quantities, without a Furnace, or Coales, or ordinary Cupell, or other Vessell.

And I remember, that by way of Approximation, I made a certain Powder, with which, without a Furnace, I have in a trice melted Lead-Oare (which very often holds Silver) into Metall, and perhaps consum'd some of the baser Metall too.

And lastly, as for the making of Emboss'd works of Wood in Molds, I am credibly inform'd by a Learned man, that it was actually perform'd lately at the Hague, by the Secretary of a forreign Embassador; but of the way I could not procure the least Hint, though supposing the truth of the Relation, I suspect it was done either by some Menstruum, that much soften'd the Wood, which may afterwards be easily harden'd again, by which way Tortoise-shell may be molded; or else, by reducing the Wood into Powder, and afterwards uniteing the parts into one Body with some very binding and thin kind of Glue, whose superfluous parts may afterwards be pressed out. And I remember, I began (but was accidentally hinder'd to proceed,) a Tryall to make an Approximation to this, by the help of a rare Glue, of which I had the hint, without being much beholding to him for it, from the practise of an Ingenious Tradesman, which as I now prepare it, is made by soaking the finest Ichthyo-Colla (*i.e.* Izeing-Glasse) for 24, or at least for 12 howres in Spirit of Wine (or even common Brandy; for the Menstruum need not be very good, unlesse for some particular uses,) When by this Infusion

sion, the Liquor has open'd and soften'd the Body (which will much swell) both the Ingredients are very gently to be boyld together (and kept stirring that the Ichthyo-Colla burn not, till all be reduc'd to a Liquor, save perhaps some strings, that are not perchance very dissoluble) when tis boyld enough, a drop, sufferd to cool, will soon turn to a very firm Gelly, and whilst tis hot it should be strained thorough a piece of clean Linnen into a Glasse or other Vessel, that may be kept well stop't; a gentle heat suffices to melt this glue into a transparent Liquor with little or no Colour, and yet this fine thin Glue holds so strongly, and binds so very fast, that having sometimes taken two ordinary square Trenchers (for the round ones are wont to be too thick) and layd the one a pretty way over the other, a little of this Liquor put between them, and suffer'd to dry of it self, united the Trenchers so fast, that when force was employed to break them, it did it else where, not where they were joynd together. So that it seems, the Gluten, that fasten'd the Trenchers together, was stronger, than that, which joynd the parts of the same Trencher to one another. The other uses of this Gelly (which by reason of the Spirit of Wine, will not easily corrupt like other Gellys) belong not to this place. Only I shall adde to our present purpose, that having taken some common Sawdust, and after having imbib'd it with melted glue, strained out slightly what was superfluous, through a piece of linnen, and shiped the rest with my hand into a Ball, this negligent Trial (which was only made to see whether a more accurate might be hopefull) made the Ball, after it had been leasurly dried, so hard, that being thrown several times against the floor, it rebounded up without breaking; but as I was saying, an Accident hindered me from prosecuting the Experiment, which therefore I recommend to you.

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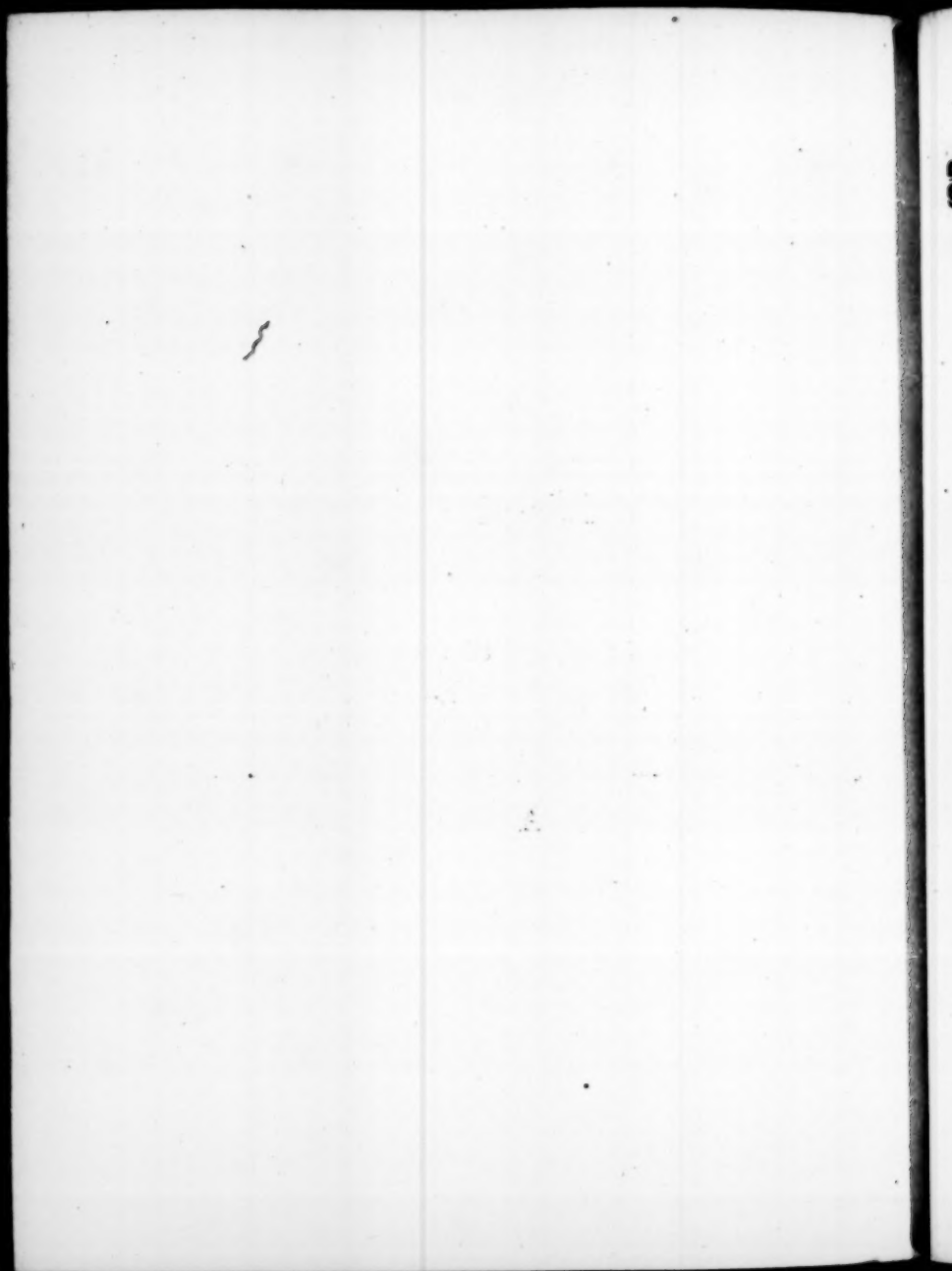
I will not now stay to tell you, *Pyrophilus*, how it may assist you toward the making such Approximations, as we have bin speaking of a little above. To take each of the difficulties, you would surmount into the several parts it may be conceived to consist of, and make an Enumeration of the possible wayes of mastering each of these, according to some Methods, that might be proposed; because to discourse of this subject would take up too much of the time allotted to the following Essays, and therefore I shall conclude *this* by observing to you, that as you are, I hope, satisfied, that Experimental Philosophy may not only itself be advanced by an Inspection into Trades, but may advance them too; so the happy Influence it may have on them is none of the least wayes, by which the Naturalist may make it useful to promote the Empire of Man. For that the due Management of divers Trades is manifestly of concern to the Publick, may appear by those many of our English Statute Laws yet in force, for the regulating of the Trades of Tanners, Brick-burners, and divers other Mechanical Professions, in which the Lawgivers have not scorn'd to descend to set down very particular Rules and Instructions.



Of doing by
PHYSICAL KNOWLEDG

What is wont to require
MANVAL SKILL.

A





*Of Doeing by Physical Knowledg what is wont
to require Manual Skill.*

OR

*That the Knowledg of peculiar Qualities, or Uses of Physical
things, may enable a Man to perform those things Physical-
ly, that seem to require Tools and Dexterity of Hand, proper
to Artificers.*

THe Particulars to be mention'd in this 8th Essay, might have been rang'd partly under the preceding Discourse, and partly under the XIth Essay, (which will be the last of this Treatise,) whose Titles are comprehensive enough to take in the Instances that make up this present Discourse; which yet I have rather chose to deliver apart, not onely because they seem somewhat differing from the Examples alledg'd in the two mention'd Essays, but chiefly because the Uses that may be made of such Instances, may make them deserve a distinct and peculiar mention. For tis both a notable Argument of the Industry of Mankind, and may prove a great encouragement to it, that the Help of Philosophie may supply the office of Manual Dexterity, Strength, or Art, and a knowing Head may do what is thought not performable, but by a skillful Hand, or an Arm assisted by some Instrument or Engine. And of these Instances (which may be justly look'd upon as so many Trophies of Humane Knowledg, and so many Incitements to Humane Industry) it will be needles to make any Division, and therefore I shall barely set them down as they come into my mind, no other Order being necessary for Particulars that are

A 2

brought

brought but as Proofs, and have not a dependency upon one another.

The Assertion, that makes the Title of this Discourse, the King of *Spain* finds true so much to his Advantage, that, if I mistake not, it amounted for a good while to divers millions yearly. For whereas formerly in the Silver-Mines of *Potozi* in *Pern*, (accounted the richest in the World) it was wont to be a very tedious, laborious, and consequently chargeable work, to sever the Silver-particles of the Oar from the ignobler parts of it, by many slow and costly, both Manual and Metallurgical Fusions, and other wayes of Segregation, much of that labour is now sav'd by *Pero Fernandes de Valesco*, who, as *Acosta* informs us, first made use at *Potozi* of the property of Quick-silver to Amalgamate with the nobler Metals. For now, by accurately grinding the powder'd and sear'd Oar with Quick silver (strain'd through a Cloath,) and Salt, and decocting them for five or six daies, in Pots and Furnaces fitted for the purpose, the greedy Mercury licks up the Silver and Gold (which it sometimes meets with) without meddling with the ignobler parts of the Oar; and being enrich'd with as much of them as it can imbibe, and diligently wash'd from the adhering *sordes*, the Amalgam is, by Distillation with a strong Fire, freed from the Mercury, which coming over reviv'd into the Receiver, leaves behind it the fixt Metals, (*viz.* Gold, and Silver,) which may be afterwards (if need be) easily reduc'd into Bodies, and parted by the common way. And by a not unlike way some of our Gold-Smiths and Refiners are wont (as themselves inform me) to regain out of the Dust and Sweepings of their Shops, the Filings and other small particles of Gold and Silver, which fall to the ground in their Operations, and in process of time may amount to a considerable value.

To make an Head, exactly representing the Size, Shape,
and

And Lineaments of the face of any living man, seems to require an exquisite skill in the Statuarie's Art; and yet at my desire, and in my presence, that was lately perform'd by a Tradesman, after the following manner. The party, whose Face was to be cast off, was laid flat upon his back, having round about the Edges of his Forehead, his Cheeks, and his Chin, something plac'd to hinder the liquid Plaster from running over on his Hair: then into each of his Nostrils was put a hollow piece of stiff Paper, of about a quarter of a Foot long, and of the figure of a Sugar-loaf, and open at both ends, that the Affusion of the Plaster might not hinder him to take Breath. And of these Pipes, (which were carefully oyl'd over,) the acuminated Extremes rested upon his Nostrils, and the other were supported by one of the Assistant's hands. Then his face being lightly oyl'd over, to hinder the Plaster from sticking to it, with oyl-Olive, and his Eyes being shut, Alabaster newly calcin'd in a Copper-Kettle, till it was as white as before, was temper'd up with fair water to the consistence of Batter, and by Spoonfuls nimbly put all over his Face, till the matter lay every where neer an Inch thick. Almost as soon as it was all laid on, it began to grow sensibly hot, and in about a quarter of an hour hardened into a kind of Lapideous Concretion, which being gently and easily taken off, shew'd us in its Concave Surface the exact Impressions made there by the parts of the Face, and even by the single hairs of the Eye-brows. In this Mould they cast a Head of good Clay, (by working it in,) and on that Head they open the Eyes, which in the Prototype and Mould were shut, and (if need be) heighten the Forehead, and make what other amendments they think fit; and anointing this new face with Oyl, they after the former manner make a second Mould (of two parts, contiguous all along the ridge of the Nose) with calcin'd Alabaster, and in this second Mould (lightly oyl'd on the inside) they cast with the same
Matter

Matter the fore part of an Head, more like the Original, than ever I saw made by the most skilful Statuary, and yet with so much ease, that the very first Tryal I made my self to cast a Face thus, succeeded.

To take the Impression of a Leaf, or other flattish part of a Plant, it may seem requisite that a man be a good Painter: and yet I found, that the thing may be perform'd, onely by holding a whole Leaf (or Sprig of Rosemary, &c.) in the Smoak of a piece of common Gum Sandarack, Rozin, Camphire, or some such Body that emits a copious and fuliginous Steam, (for which purpose I have made use of a common Link, when that was most at hand:) for the Leaf being well black'd by these Fumes, and plac'd betwixt the Leafs of a Sheet of white Paper, if you carefully press the Paper upon the Leaf with the Haft of a Knife, or some other smooth thing, you may thereby print on the Paper in a few moments the exact Size and Figure (but not Colour) of both sides (but especially the back-side) of the Leaf, with the very Ramifications of the Fibres that are disseminated through it. And this may be perform'd, though not so lively, by blacking the Plant, whose picture is required, with the fumes of a Candle or Taper, (especially if it be of Wax) in stead of those of the aforementioned Resinous Concretes, and afterwards proceeding as in the former Experiment: which sometimes may be of good use to you, when you turn Botanist, and in your Travels meet with Plants whose pictures you think worth having, but have not time or conveniency to Draw them.

Another Instance, of the same import with the foregoing ones, may be afforded us by the Art of Etching, whereby Copper and Silver-plates may be enrich'd with Figures, which may seem to have been made by the Tool of some excellent Graver; and yet those Engravings do not require the presumed Manual skill, and are made without such Tools, by having a *peculiar sort of Varnish* (for on the goodness of

that, depends much of the success of the Operation) on the Plates, and drawing on it the Figures to be engrav'd. For all those Lines, where the Plate is freed from the Varnish, by skilfully temper'd *Aqua fortis* (from whose Corrosive violence the remaining Varnish secures the rest of the Plate) may be so curiously wrought on by those few Artists that are skilful in it, that I have very seldom seen lovelier Cuts made by the help of the best temper'd and best handled Gravers, than I have seen made on Plates Etch'd, some by a French, and others by an English, Artificer.

But the knowledge of the Physical properties of things may sometimes enable a man to perform, not onely things to which Mechanical Tools and Manual Dexterity seem to be necessary, but some things also whereto even Mathematical Instruments, and skill in Mathematicks are thought requisite; of which I shall at present propose a Couple of Instances.

In the elsewhere mention'd French Abridgment of *Galileo's* Italian Book, I find a passage very pertinent to our present Design, which agreeing very well with our Observation of that kind, we shall propose it a little more clearly as follows.

*Nouvelles Pen-
sées de Galilée
liv. 1.*

Suppose in a high Church (the Book exemplifies *Nostre dame*) the great Candlestick that hangs from the top of the Church being made to swing, a Philosopher that has observ'd that the Vibrations of a Pendulum, though the Arches it describes be unequal, are in the sense formerly declar'd equitemporaneous; and that, when the Strings, at which such Pendulums hang, are very unequal, their Lengths will have the same proportion, as is between the Squares of the Numbers of their single Vibrations perform'd in the same time: Suppose, I say, that such a Person have a Pendulum with him, whose String (which may be of any length, so it be determinate) is, for Example, a Yard long, it will
not

6 *Of doing by Physical Knowledge*

not be difficult for him, without any Quadrant or Geometrical Instrument, to find out the length of the String that supports the Candlestick, and consequently the height of the Church. For the Candlestick and the short Pendulum being made to swing, beginning both at the same time, let us suppose, that when the Candlestick has made nine Vibrations, the Pendulum of a Yard long has made 54, the Squares of these two Numbers will be 81 and 2916; and because, as we lately said, the length of the Pendulums will have the same proportion with the Squares of the Number of their Vibrations, dividing 2916 by 81, the product will be 36; which shews, that the String, at which the Lamp hangs, is 36 times as long as that of the shorter Pendulum, and consequently a Yard (containing 3 Feet) amounts to (36 Yards or) 108 Feet.

Upon the knowledge of another Physical property of heavy Bodies I remember I have grounded a way to measure vast Heights and Depths without any Geometrical Instruments, and in such cases where such an Instrument cannot be employ'd, by the help of a Pendulum; which, because in this case it must be very short, will require an attentive and expert Observer. For it being known that a Stone, or a piece of Lead, or the like solid weight, falling from a height does so accelerate its Descent, that the differing spaces it has transmitted, at any differing times assign'd, will have betwixt them the same proportion with the Squares of the times, wherein the respective spaces were transmitted; if it be once known by diligent Observation how far a Stone, or such a solid Body, (whose greater or lesser bulk is not here considerable) does fall at the end of the first Second-minute of its motion downwards, it will be easie enough for a Naturalist, vers'd in the Doctrine of Proportions, to collect from the time that the Stone imployes in descending perpendicularly from the top of a high Tower or Steeple, how high
that

that Building is. This way of measuring, provided Attention and Accuracy be not wanting, we found agreeable enough to divers Observations of our own and our Friends; and by this way one may measure the Depth of a Well (to the surface of the Water) how deep soever, though the bottom, as tis usual by reason of the darknes, cannot be seen, which makes the depth unfit to be measur'd by Quadrants, and such like Geometrical Instruments: For if at the same time that you let fall a Stone or other Weight, you also let go a Pendulum that vibrates Quarter-seconds, that is, makes two Excursions and as many Returns in the 60th part of a Minute, and reckon its Vibrations till you hear the noise made by the Stone dashing against the Water in the Bottom of the Well, you may easily enough collect the Depth. For let it be supposed, that it be found by Experience, that a falling Stone, or other like Weight, do in the first Second-Minute of its Descent dispatch (as the diligent *Mersennus* affirms himself to have often found) 12 Feet, (which I understand of French, not having found it hold in English measure,) and let us also suppose the Pendulum to have perfected 6 single Vibrations before the dashing of the Stone against the Water was heard; if we proceed according to the Rule formerly given, we shall find, that if the time, wherein the falling stone transmitted those spaces that are to direct our Calculation, be 1, and 6, the Square of those two Numbers being 1 and 36, the Stone must have fallen at the end of the 6th Second 36 times as far as at the end of the first. And since by Observation (about whose Accurateness we need not be solicitous here, where we design onely the giving an explanatory Example) a falling Stone in the first Second descends 12 foot, we need but multiply 36 by 12, to obtain in the product 432, the perpendicular Depth of the Well to the surface of the Water. And the same number may be collected, and perhaps you will think more easily, by

supposing, as *Galileo's* Experiments seem to prove, that a falling Body accelerates its Descent according to a Progression of odd Numbers, beginning from an Unite; so that if in the first Second-minute, or any other determinate part of time, it falls one space, whatever that be, in the next Second it will fall 3 spaces, and in the third 5 spaces, and so onwards; according to which reckoning, if the falling Body be suppos'd to descend 12 foot, during the first Second it will descend 36 (besides the former 12 in the next Second,) in the third 60, in the fourth 84, in the fifth 108, in the sixth 132, which summ'd up together amount to 432. And by the same way one may measure the Height of divers Precipices how great soever, as far as one can reach downward in a perpendicular Line. And one may also give some guess at the depth of some Volcans, which are not accessible to those that know but the common wayes of Mensuration, or which have burn'd the Ropes, and even melted down the Chains and Weights, by which some Curious persons have attempted to fathom their Depth. 'Tis true, that in Mathematical rigour some Abatement ought to be made, because the Stone strikes the surface of the Water, or the bottom of the Precipice, some little while before the sound, produc'd by that stroak, can arrive at our Ears. But unless the Height or Depth to be measured be very extraordinary, this allowance, for the delay of the Noise, either may be neglected without much Inconvenience, or in probability will scarce exceed a quarter (or at most half) of a Second; since, as has been elsewhere noted, it has been found by Observation, that a Sound in the Air moves above twelve or thirteen hundred foot in one Second. And in what I have here deliver'd concerning the way of measuring Depths and Heights by the falling of a heavy Body, I have been much confirm'd by an Observation I chanc'd to meet with in an Outlandish Book, which I have not now by me to look out the place, where
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the Mathematician that writes it, who seems to have been a diligent Observer, affirms, that he found a Weight let fall from the top of a Church or Steeple (for I remember not which, nor is it material,) so high as to amount to 300 foot, to reach the Ground in about five Seconds; which agrees very well to what we have been delivering. For supposing the Weight to fall 12 foot the first Second, at the end of the fifth Second it must have fallen 25 times as far, (1 and 25 being the Squares of the Numbers of the Seconds of time,) and consequently 300 foot.

To slit (or divide transversly into Flakes or Leaves) so thin a piece of Metal as an old Groat, which seems not to exceed, if it so much as equal, the thickness of a Leaf of white Paper, may be thought, if it be feasible, to require some very subtle dividing Instrument, with an Edg finer than that of a Razor; and yet the way of performing this by Physical means, is but an almost ludicrous Experiment, which (if you know it not already) is easily thus made. Take three Pins, and stick them in the form of a Triangle, at such a distance from each other, that the Groat may rest upon the heads of them: put upon this thin piece of Metal almost as much flower of Brimstone, or at least finely powder'd Sulphur, as will conveniently lie on it; then kindling the Sulphur, let it burn out of it self; which done, take off the Groat, and throwing it hard against the Floor, the upper part, with the adhering remains of the Sulphur, will be parted from the lower: which (lower) if the Coin were not very thin, will retain its former shape. I have observ'd in this Experiment a pretty Circumstance or two, the knowledge of which is very apt to be misemploy'd, and need not here be mention'd: though I would not silently passe by the Experiment it self, because, as ludicrous as you may think it, it may suggest uncommon Speculations to a considering Naturalist, and also intimate a way of preparing Silver, of

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which

which I may elsewhere tell you the practical Use.

He that takes notice of so pretty a variety of Colours and Shapes, as may be discern'd on a skilfully made sheet of Marble paper, will be apt to conclude, either that the differing Colours were laid on one by one with a Pencil, which would require a great deal of time and pains; or that the Sheet was marbled by being printed off from some Plate, on which the differing Shapes were cut or engraven, and the differing Colours singly plac'd, which would require yet more labour, and a greater *apparatus*; whereas the whole Sheet is painted thus variously and delightfully at once, and in a trice, by the contact of the surface of a Vessel full of Water, on which the Colours (first blended a little by a quick and easie motion of the Artist's hand) are so order'd, as to swim without being confounded. This Artifice hath, as I am inform'd, been deliver'd by the Curious *Kircherus*. But if you have a mind to know the Particulars of it more fully, you may command me to acquaint you with what I have learn'd from Experience, by which the Practice is suppos'd to have been of late improv'd.

If it were propos'd to free weak spirit of Wine or *Aqua vita* from a great part of its Flegm, the Generality of Distillers would think it not to be effected, but by the help of Fire and a Furnace, an Alimbeck, or some other Distillatory Vessels; and yet, without the help of any of all these Instruments, I have sometimes taken pleasure to deflegme Brandy, (as they call weak spirit of Wine of the first Distillation,) onely by putting it into Salt of Tartar. For considering the faculty this Alkalizate Body has to attract (as men commonly speak) or imbibe the Aqueous particles that swim in the Air, and resolve it self with them into that Liquor, that the Chymists call Oyl of Tartar *per Deliquium*, there seem'd sufficient reason to expect, that the same Salt being put very dry into phlegmatick spirit of Wine, would embody with
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What is wont to require Manual Skill.

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the phlegmatick parts, with which, if it were not overcharg'd, it would probably keep them separate from the more spirituous Liquor; since such Oyl of Tartar as I have just now mention'd, and dephlegm'd spirit of Wine, will swim upon one another without mixing; and accordingly I have sometimes taken pleasure, by putting a sufficient proportion of dry Salt of Tartar into Brandy, and leaving it there for some time (for the Experiment will, to be compleated, require some while) to make some separation of a great part of the Flegm, which by degrees dissolving the Salt, will reduce again part of it into a Liquor, that will keep its surface distinct from that of its supernatant Spirit, and if confounded therewith by the shaking of the Glass, would speedily part from it, and regain its own station; and if you would have a separation of the phlegm begin to appear quickly, you may compass what you intend, by tying up a convenient quantity of dry Salt of Tartar in a dry rag of Linnen cloth, and immersing it a little while in the Brandy, and then lifting it up a little above the Liquor, for the phlegmatick parts being copiously imbib'd in the Salt, which will be thereby resolv'd into a ponderous Liquor, will in drops (whose descent will be distinguishable enough, if the Glass be held against the Light) fall to the bottom of the spirit of Wine. And lest you should suspect, that this descent comes not from their Weight, but from the force they acquire in falling through the Air, you may keep the Rag immerst beneath the surface of the Liquor, and yet may perceive the Efflux and Subsidence of the Lixivium we have been speaking of.

There are some cases, wherein Bodies, that are to be held very softly, are either so brittle, that 'twould be hard to hold them fast enough without danger of breaking them; or else so small, and so inconveniently shap'd, that 'twould be very difficult to procure Instruments to lay hold on them, and keep

keep them movelesse in the Instrument: and in several such cases the use of Tools, to hold fast such Bodies, may be advantageously supplied by Artificial Cements. As I remember I have known the Glasse-grinders, instead of more Mechanical Tools, imploy Pitch, melted and made up with Ashes, very well stirr'd and incorporated with it, into a stiff Past. For this Mixture, being by a fit Heat brought to a convenient Softnes, the Glasse to be ground or polish'd is bedded in it, in what posture, and as far as, the Artificer pleaseth; and by the same Mixture the Glasse being fasten'd, at the end of a Stick or some proper Instrument of Wood, the Glasse, upon the cooling of the Cement, remains firmly fastned, till the Artificer have done with it what he design'd; after which, by softning the Cement with Heat, he can readily take it off again.

And even the Diamond-Cutters, who, to grind those Stones into Shapes, are wont to imploy a very vehement Attrition, make use, for holding their Diamonds, especially when they would polish them, of a Cement, the like to which I remember I have some times made to other purposes: for themselves have confess'd to me, that they made theirs chiefly of Rosin, melted and brought to a stiff Past with fine Brick-dust, to which one of the Eminentest of them for skill adds a proportion of Sealing-wax; (I told him I preferr'd plaister of Paris before Brick-dust, and he told me he did the like.)

And indeed by variety of Cements we may be assisted to make divers Experiments, that we could not otherwise make so well, if at all; for which reason I have been somewhat Curious about making a pretty number of such Mixtures, whose Compositions you may command of me.

There are divers Artificers, especially those that slit and polish Chrystal, Agats, and other hard stones, and cut Seals in Gems, who have need of Powders of Emery, of differing degrees

degrees of fineness, and some of them extremely subtle: to obtain these one would think it necessary to have variety of Searces, and some of them as fine as tis possible. But the skilfullest Artificers judg they can obtain their desire much better by fair Water, than by the best Searces. For having in a Mortar beaten the hard Body of Emery; as long as they think necessary, they put the powder into a Pail or other fit vessel full of Water, and then with a stick, or some such thing, they stir very well all that is at the Bottom, that it may be rais'd and thoroughly mingled with the Liquor; then pouring it out into another vessel, the grossest, and the most ponderous Grains of the dispers'd powder, will first fall to the Bottom, and give a powder lesse gross than that which remain'd in the first Vessel, (which may be again beaten small in the Mortar.) Afterwards they powr the troubled Water of the second vessel into a third, and there suffer the Dust to subside, and then decanting the Liquor, if this Dust be not yet fine enough, they trouble the Water again, and after a little while powr it off either into one vessel, or two, or more successively, according to the exigency of their uses; and then suffering the transvated Water to settle for some Hours (more or fewer,) as the dispersed Dust is more or less light, they decant the Liquor, or suffer it to exhale, and take the remaining powders, of which that which settles slowest will oftentimes be strangely subtle. And by this way, if a man will have patience to pour successively the troubled Liquor into Vessels enough, and give the dispers'd powder a competent time to let fall the lesse light parts, before the upper part of the water be pour'd off into the vessel tis finally to settle in; he may obtain several degrees of powders, less and less grosse, and some so fine, as one would admire how twas made so. And this (*Pyr.*) I the rather mention to you, because tis not onely from Emery; but from divers other Bodies that one may obtain extremely minute,
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and (as they speak) impalpable Powders, of great use in some of the most Curious Trades, and perhaps in Physick too. For I may elsewhere tell you, how I apply this way to Magisteries of Chrystal, and of Gems, and even to *Crocus Martis*; the naming of which last puts me in mind to add, That a Chymist much priz'd for finer *Crocus Martis*, than others of his Profession, and thereby enabled to sell it at an extraordinary rate, confess'd to me, that 'twas to the Artifice I have been commending, that the *Crocus* he sold ow'd all its Advantages.

It has long been, and still is in many places a matter of much trouble and expence, as well of Time as Money, to cut out of Rocks of Alabaster and Marble, great pieces, to be afterwards squar'd or cut into other shapes; but what by the help of divers Tools and Instruments cannot in some Quarries be effected without much time and toyl, is in other places easily and readily perform'd, by making with a fit Instrument a small perforation into the Rock, which may reach a pretty way into the body of it, and have such a thicknesse of the Rock over it, as is thought convenient to be blown up at one time; for at the farther end of this Perforation (which tends upwards) there is plac'd a convenient quantity of Gunpowder, and then all the rest of the Cavity being fill'd with Stones and Rubbish strongly ramm'd in, (except a little place that is left for a Train,) the Powder by the help of that train being fir'd, and the impetuous flame being hindred from expanding it self downwards, by reason of the newly mention'd Obstacle, concurring with its own tending another way, displays its force against the upper parts of the Rock, which in making its self a passage, it cracks into several parts, most of them not too unweildy to be manageable by the Workmen.

And by this way of blowing up Rocks a little varied and improv'd, some ingenious Acquaintances of ours, employ'd by

by the Publick to make vast Piles, have lately (as I receiv'd the account of themselves) blown up or scatter'd, with a few barrels of Powder, many hundred, not to say thousand, Tuns of common Rock.]

To give small Glasses the shape that is requisite to fit them to serve for Covers to the Dial-plates of Watches, and for other purposes, to which Artificers sometimes employ them, one would think it necessary, that they should be ground, or otherwise wrought, with Tools, by a skilful hand, to give the Glasses the Concave, as well as the Convex, figure they ought to have. And yet I have learn'd by tryal, that a flat plate of Glas of a competent thicknes, that has its two surfaces smooth and parallel to each other, being carefully laid upon a deep Ring of Iron, or a shallow and hollow Cylinder of the same Metal, and of the Diameter required, so that the edge of the Glas (which is to be reduc'd to roundnes) may every where rest upon that of the Cylindrical piece of Metal; the heat of the fire, warily and skilfully administred, will so soften this Plate of Glas, that its own weight will so depresso the middle parts, that the Glas will thereby obtain the Figure required. And though such Glasses do not constantly fall just into the desired figure, yet when they are skilfully order'd, they fall into it so often, that I am told, that some Ingenious Artificers have quitted the ordinary way of making Covers for Watches, for that we have been describing; which though not free from Casualties, is yet so much more cheap and easie.

We have in some parts of *England* various kinds of Talk, or *Lapis Specularis*, (several of which I have been Possessor of,) and of some of them there is so great plenty, that one may procure good store for little or no charge: but the reducing of a great Lump of this Talk to fine powder, it must be done the common way, by beating it in Mortars, and searcing it often, will require much time and pains; but,

as I have several times tried, the smaller pieces may, by the help of an actual flame, be quickly reduc'd to a Snow-white *Calx*; so by the Experiment of a sagacious Acquaintance of mine, even great Lumps of it may, almost in a trice, be brought to fine powder, by heating them red hot, and casting them, whilst they are so, into cold water, whereby there will presently be made a Comminution of them into a fine, and as it were mealy *Calx*.

The ground of this Operation is much the same with that, whereby some Chymists granulate Masses of Gold and Silver, when they pour the strongly melted Metal from a competent height into cold water, whereupon there happens a Diffilition of the parts of the Metal, many of which fall to the bottom in little fragments. But the more easily fusible metals, Tin and Lead, may be quickly and better granulated by the Mechanical way, freshly mention'd, as to Talk. I remember I was wont (especially if the Ignition and Extinction were repeated 2 or 3 times) to reduce Chrystal Flints, almost in a trice, to a fineness to be easily brought to a very subtle Powder, proper to make *Amanfes* (or counterfeit Gems) of.

The mention I have already made in this Essay, of what may be perform'd by the faculty that burnt Alabaſter, made liquid with Water, has to grow hard again, puts me in mind of another Instance, very properly referable to the Subject of this Essay. For one that beholds how curiously Oranges and Lemmons, and other Fruits, are counterfeited in Wax, would imagine, that so lively a representation of them could not be effected, but by a hand, as skilful at least as that of a Painter; since by this Plastick Art, not Oranges, and Lemmons, &c. in general, but this or that particular Orange or Lemmon may be most lively represented; and yet you may learn this Art within one hour or two, the thing being performable easily and quickly: for having the Orange &c. we would

would imitate, we bury it half way in a Coffin of Clay, whose Brim, together with the extant part of the Fruit being oyl'd over, to keep the mixture from sticking, the temper'd Alabaſter (or plaſter of Paris) is nimble laid on to a good thickneſs, and, upon its Concretion, remov'd, whereby you obtain an Half-mould for that part of the Orange: then the formerly latent half of the Fruit being likewise plac'd uppermoſt in the Half-mould, which ſhould have ſome pretty deep Notches cut in the Rim of it, which, with the protuberant part of the Fruit, ought to be oyl'd, the temper'd Mixture is likewise put upon that, and thereby an exact Mould is compleated, at any convenient part of which a Hole being made, to pour in a little temper'd and colour'd Wax, when tis brought by Fuſion to a due Heat, (for every degree of that Quality is not convenient,) ſhaking the Mould nimble and every way, the Wax comes to be ſo applied to the internal ſurface, that when the Mould is cold, and the parts taken aſunder, you have an Orange of Wax very lively repreſenting the Original.

There are ſome Circumſtances belonging to this eaſie and delightful Art of Moulding and caſting in Wax, (which is pleaſant enough to be practic'd even by Ladies) that I purpoſely omit: what has been mentioned being ſufficient to ſhew you as much as is neceſſary for my preſent purpoſe. And I the rather pitch on this Experiment, becauſe it may afford us another Inſtance, not impertinent to the deſign of this Tract. For one that ſhould ſee how great a Cavity is left within the counterfeit Orange, would think that there were ſome great and rare Artifice requiſite to caſt it thus hollow, and make ſo ſmall a quantity of Wax reach to the counterfeiting of ſuch a Fruit; whereas the bare ſhaking of the Mould when the melted Wax is in it, together with the expaſive endeavour of the included Air, applies the Wax to every part of the inſide of the Mould, and thereby turns it

into one great Film, which one would think it very difficult to separate, without injuring it, from the Mould, to which tis applied so close; and indeed it might be so, if Nature did not again assist the Artist, by making the Mixture, when it cools, shrink a little, and thereby part easily from the Mould it stuck to.

But one of the prettiest and the strangest Artifices that belong to this Essay, is that whereby the knowledge of a few unheeded Physical properties of two or three Bodies, may enable a man to perform that, which seems to require, not onely good Tools, and great Dexterity in the Art of Graving, but likewise an exquisite skill in Caligraphie, or the Art of writing fair: for I know a Graver, famous for skill in his Profession, who writes, as I have had good opportunity to observe, but a bad hand; and yet this man with his Tool writes rarely well, and will imitate and emulate the finest Copies of the choicest Writing-masters, so that even *Virtuosi* have much admir'd how a man, with a stiff Iron-Tool upon a tough Copper-plate, can write incomparably fairer than the same person can with a good Pen upon Paper. But to ease you somewhat of your wonder, I shall adde, that though this Artifice be kept for a choice Secret, and though I could not learn a considerable Particular or two, which belong to the Delicacy of it, yet (partly by putting Questions, and partly by some Tryals of my own) I attain'd to the substance of this Mystery, as they call it, which seems to be this.

A Writing-Master, or some other that writes a very fair Hand, is desir'd to write a Copy, or what else is to be engraven, with a peculiar kind of Ink, which differs not in show from common Ink, being fully as black as it. Then they take a very clean and well-smooth'd Copper-plate, which being moderately warm'd, is to be so rubb'd over with a certain white Varnish, or something equivalent (to be mention'd

a little beneath,) that when the Plate grows cold again, it may be thinly and evenly cast over with a kind of Skin or Film (if I may so call it) of Varnish; then lightly moistning the Paper, that it may part with its Ink the more readily, the Written side is to be laid on the prepar'd side of the Plate, and That, together with the Paper, being pass'd through a Roling-Press, enough of the Ink will stick (but in an inverted posture) to the Varnish, whose Whitenes renders the black Letters very conspicuous; so that tis easie with a Needle (fitted with a wooden Handle) to draw over the very same Lines and Stroaks through the yielding Varnish upon the Metalline Plate, whence they may, after the Plate is by Heat, or otherwise, freed from the Varnish, be completed with a Graver; and lastly, when the whole Engraving is finish'd up, may be printed off in a Roling-Press like ordinary Cuts. And even without a Roling-Press I have sometimes taken off written Characters, onely by laying the moisten'd Paper very smooth upon the Varnish'd Copper, and rubbing it hard thereon with a Convex piece of Glass, or some such smooth and hard Body, whose pressure makes the Ink stick to the Varnish, *for which I have us'd the purer sort of Virgin wax*, if the Ink be good, and have been laid on plentifully enough by the Pen. (That Ink which I most us'd, I made onely of fine *Franckford Black*, as the Painters that sell it are wont to call it, by grinding it little by little, but very diligently, with Water, till it had attain'd the consistence of a somewhat thick Ink; in which this onely Circumstance is carefully to be observ'd, that no Gum be added, as is usual in other Inks, least that hinder its coming off.)

And here twill not be impertinent to the Argument in hand to adde another Artifice, whereby a printed Cut may be so far taken off, that at least the Out-lines and the principal Stroaks may be ready copied for the Gravers hand, by which way, besides other Uses that may be made of it, Copies

pics of rare and choice Pieces may be procur'd, and the perishing or want of the Originals supplied; if then the Print to be taken off be recent enough, (as it is wont to be, if it exceed not a Year, or perhaps two,) then the Paper needs only be well moisten'd, as if it were to be printed off at a Rolling-Press (with the Ink, proper to which tis suppos'd that the Cut was, as usually Cuts are, printed off;) but if the Picture or Scheme be more ancient, it must be laid all night to soak in water, and then hung in the Air, till it have but such a degree of Moisture as makes it fit for the Rolling-press: The Paper being thus prepar'd, either by bare wetting or by steeping, the printed side is to be laid upon a Copper plate, thinly cas'd over, as was formerly directed, with Virgin-wax; for the Plate and Paper being put into a Rolling-press, the Compression of that will make the moisten'd Ink stick to the pure Wax, which consequently will take the Impression of the Cut, or at least of the Outlines and chief strokes of it.

There is another thing which seems above all these to require the express and immediate Operation of the Hand, and it is a Physical way, if I may so speak, of transcribing a whole page of a Letter, or other Writing, all at once. Whether this can be perform'd cheaply and easily enough for common use, is hereafter to be consider'd. But that abstracting from these Circumstances tis possible to be done, (by an Artificial Application of Physical things) I have been perswaded by some Experience, of which I may in one of the following Papers give you a more particular Account, than I now conveniently can.

In the former part of this Essay, *Pyrophilus*, I have presented you some Instances, wherein Physiological Knowledge may be substituted for Manual Dexterity, Mechanical Tools, and even Mathematical Instruments: but now to shut up this Discourse, I shall subjoin a Relation that will manifest, that
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even a Mathematician and an Engineer may sometimes performe that by the knowledg of a slight Physicall Quality of obvious Bodies, which without that knowledg, all his skill in Mathematical Disciplines, and his vast and Artificial Engines, will not have inabled him to accomplish. For who would think that by a comparatively few Pounds of Water (perhaps the Moisture of the Air in wet Weather might have suffic'd) a massy Body of peradventure some hundred thousand pounds in weight should be rais'd, and yet that this was perform'd at *Constantinople*, is one of the remarkablest things I remember I met in the ingenious account of his Voyage, that is given by the Learned *Busbequius*, Embassador from the King of the *Romans* to the *Turkish* Emperour. His words are these. *De Obelisco, cujus supra memini, qui est in Hypodromo, sic Græci commemorant; à basi convulsus multis seculis jacuisse humi: tempore posteriorum Imperatorum reperiunt Architectum, qui operam suam in eo sua basi restituendo deferret; illumq; postquam de pretio conventum esset, ingentem apparatus organorum ex trochleis & funibus præsertim instituisse, quibus lapidem illum ingentem erexerit, sublimemq; eo erexerit, ut uno tantum digito abesset à dorso Astragalorum quibus imponi debebat, tum indicasse populum spectatorem olem illi & operam tanti apparatus perisse, magnisq; denuo laboribus & impensis opus instaurandum: at illum minimè diffisum perito à rerum naturalium scientia subsidio iussisse afferri immensam aqua vim, qua multis horis in Machinam illam injecta, funes quibus Obeliscus librabatur, sensim madefactos rigentesq; (ut eorum est natura) se contraxisse, sic ut Obeliscum altius sublatum in Astragalis statuerunt, magna cum admiratione & plausu vulgi.* And for confirmation of this Narrative, it may be added, that the same thing is mention'd by good Authors, as having been practic'd elsewhere; and a like story is allow'd, and somewhere made an Argument of (to another purpose) by that great Master of

*Aug. Busbequius
Epist. 1. pag. 69.*

Mechanicks Galileo himself.

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To catch any store of Fish the ordinary way, you know tis customary that even in Rivers, either store of Angles, and some skill in using them, or Nets, or some other Artificial Instruments be made use of; and if it be in the Sea that men are to fish, large Nets or some peculiar Contrivances are employ'd as necessary; and one would not expect from such people as the *Americans*, easier wayes of Fishing than these, and yet these illiterate Barbarians, by having found out (probably by chance) the Physical property of a Wood, make that serve them to catch Fish in great plenty, and with as much ease. For our late English Navigators have observ'd, as their Voyages witness, that in some parts of the West-Indies, the Natives, by impregnating the Water with this Wood, do so stupifie the Fish, that rolling up and down upon the Surface of the water, as if they were fox'd, they are easily taken up in great numbers in their hands: which Relation of our Seamen, I therefore, notwithstanding its strangeness, scruple not to alledge, partly because that though we do not use a simple Drug, much lesse a Wood, for the same purpose, yet our Foxing-stuff (as they call it) which is but a slight Composition, produces Effects not much inferior; and partly because having purposely enquir'd of a Learned Physician, that came not long since out of a part of *America*, where this practise is in request, he assur'd me, that he saw the *English* themselves use this way of Fishing, onely by tying a Log of this Wood, to which (for what reason I know not) they have given the name of Dogwood, to the Stern of their Boats; so easily does the odd Property of this Wood enable them, that make use of it, to catch Fish.

To take off the Hair is generally suppos'd to require both a Rasor and other Implements, and the Manual skill and Operation of a Barbour, especially if the Hair be grown under the Arm-pits, and in other places, which an inconvenient situation or Figure makes to be of difficult access; and yet
by

by the knowledge of a property of that Natural production, formerly mention'd in the VI Essay, under the name of *Rufma*, the Hair may be, without Instruments, taken off from any part of the Body, and that not onely in much shorter time than is requir'd to Shaving, but, as far as the Eye is wont to discern, by the roots, which makes it much longer before the part be again cover'd with hair of the former Dimensions. The way us'd in the East to effect this, the fore-cited *Bellonius* annexes, in stead of which I shall tell you what I try'd with a parcel of it, brought into *England* before I met with his Observations about it. We mixt the fine Powder of it with an equal weight of strong powder'd Quick-lime, (*Bellonius*, probably not without reason, prescribes but half as much Quick-lime,) and having suffer'd them to soak together a short while in a little fair water, we thinly spread the soft Past or Slime, made by the water and Ingredients, upon that part of the Body which we design'd to free from Hair; and having suffer'd this Mixture to stay on about 3 minutes (or 60 part of an Hour,) measur'd by a Minute-watch, (our Author prescribes as long time as is requisite to the boyling of an Egg,) we wip'd it off with a Linnen Cloath dipt in warm water, and found the Hair taken off by the roots, without any inconvenience to the part, that we could discern, though I several times shew'd the Experiment to others, and the Trial of it was more than once made upon my Self.

It may seem scarce possible, without the help of Water, or any Engine made with Springs or Wheels, to measure Time, though but for a little while, as exactly as our best Clepsidra's, Clocks, or Watches are wont to do. And yet (which is now a known, and almost vulgar thing) such an account of Time may be kept by him that has observ'd, that the Vibrations or Diadroms of a Pendulum are made in sensibly equal Spaces of Time, though the Arches continually decrease that are made by the swinging Pendulum, (as you

know they now call a Bullet, or the like weight hanging at the end of a String from a Naile, or other fixt Supporter.) For by so slight a thing, as I have been mentioning, if you watchfully observe and reckon the Returns that the swinging Weight makes towards you in a Minute, or other determinate space of Time, doubling the Number of those Returns, and adding thereto an Unite, if you left off counting, when the Weight was at the further end of the Arch describ'd by its motion, you may obtain a more accurate Division of Time than by any of the formerly known wayes of measuring it. For if You make your Pendulum of the length of very little (perhaps a Tenth of an Inch) less than ten Inches (or twelve parts of our English Foot,) accounted from the Naile, or other thing whence tis suspended, to the Center of the Pistol-Bullet, (or the like small round Weight;) and, removing this a pretty way from the Perpendicular it naturally rests in, suffer it to fall gently out of your hand, each of its two swinging motions (the one whereby tis carried from you, and the other whereby it returns to you) will be (especially whilst the Arches are of a moderate length) Physically *equitemporaneous*; and these motions will very distinctly enough, to an attentive eye, divide a Minute or sixtieth part of an hour into an hundred and twenty parts, (call'd Half-Seconds,) and will consequently divide an Hour into seven thousand two hundred parts, if not perfectly equal, yet lesse unequal, as to sence, than the Divisions of Time made even by good Watches are wont to be. And therefore this way may be of very great use in making Astronomical and other Observations, that last not long, but require exact measures of Time. And by the help of a Pendulum a skilful Musitian of my Acquaintance, teaches his unpractis'd Scholars to keep time when they sing in his absence. But when we measure Experiments by the Excursions and Returns of a Weight, the best way is to make the Duration of the Pendulums whole motion

NB. The Author has elsewhere shown, that the English Foot differs very little, if at all, from the ancient Roman.

motion (before it come to rest) as long as the place where the Experiment is made will permit, renewing now & then, if need be, the Impulse given to the Weight, when the Arches begin to grow too short, that being increas'd, the Vibrations may be the better reckon'd.

The mention I have been making of the Uses of Pendulums, joyn'd to that I lately made of *Æquivelocity* of Sounds, bring into my mind another Instance pertinent to this part of our Discourse. For tis not impossible by the knowledg of the Velocity of a Sound's motion in the Air, and the *Æquivelocity* (as to sense) of great and small Sounds, to measure without Geometrical Instruments, in some cases the Breadth of a River though exceeding wide, or the distance of the place one stands in, from the top of a high Tower or Hill on the other side of a River, or situated in some inaccessible place, and this in cases where the difference of Stations usual in Geometrical Mensurations is not allowed. The way is evident by what is elsewhere delivered. For it having been found by *Mersennus's* Tryals that Sounds (as well small as great) do move in a Second (as they call the 60th part of a Minute) 230 Fathom, or thirteen hundred and eighty foot; if I see my Correspondent fire a Gun on the other side of the River, or if I see Muskets or other Guns casually fired on some Tower or Bastion, though never so far distant, and never so inaccessible to me, tis easie for me by letting fall a short Pendulum, as soon as I see the flash of light produc'd by the kindled Powder, and by reckoning the Vibrations (made by that short Pendulum, which distinguishes *Seconds* into halves or quarters) that shall happen to be made before the Noise arrive at my Ear, to know how far off the place, where the Gun was discharg'd, is from that I am in. As if a Correspondent, standing over against me on the other side of a River, or some Souldiers being there exercising, I see the flash or smoak of a Musket or other Gun two Se-

conds sooner than I can hear the Report of it, I may conclude the River to be 2760 foot broad; and if a Peece of Ordnance being fir'd upon the Tower of a besieg'd place, the noise arrive at my Ear in $\frac{1}{2}$ a Second, I may collect 690 foot to be the distance betwixt that Gun and my Station. And by this means may that Probleme be perform'd that we elsewhere mention as a thing, which, when nakedly propos'd, may seem impossible. For if I see a Ship at Sea be shooting, whether in earnest, or for Salutation, or for Joy, tis very possible for me to measure, without Geometrical Instruments, how far tis off, though the Ship it self be under Syle. For Vessels that fire Guns, usually firing more than one, whether to offend their Enemies, or to salute their Friends, tis easie to take warning, by the first Gun, to be in readinesse with a short Pendulum against another to be fired, and in this way of measuring (though not in any other yet known) one may take Distances in the darkest night. For it matters not whether I see the Ship or place, whose remoteness from me I would know, provided by some Candle or Taper I see my Pendulum before the Flash of the fir'd Gun, which will sufficiently discover its self by its own Light. And (to add That upon the by) I have had sometimes Thoughts, that if the Velocity of Eccho's, which are but reflected Sounds, be so well determin'd as that of direct Sounds, Navigators might sometimes make useful Estimates in dark nights, whether they be neer Coasts, or considerably great Rocks. For though upon discharging a Gun they cannot conclude how neer the Shore they are, because there may be parts of it lesse remote than thole that send the Eccho; yet if they follow very quick upon the discharge of the Gun, they have reason to suspect that the Shore, whose approach the Sea-men do so justly fear in the night, is at least as neer as the Vibrations of the Pendulum inform them that the Ecchoing place is.

ESSAY X.

Of Mens
GREAT IGNORANCE
of the Vses of
NATVRAL THINGS.

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ESSAY X.

Of mens great Ignorance of the Uses of Natural things.

OR

That there is scarce any one thing in Nature, whereof the Uses to Humane Life are yet thoroughly understood.

THIS being an entire Proposition, and clear enough of it self, will not need to be Explicated but Evinc'd: And evinc'd somewhat solemnly it will require to be, not onely because tis a Paradox, but such an one as will meet with a peculiar Indisposition to be entertain'd; since Men cannot allow this Paradox to be a Truth, without such a Confession of their Ignorance as must implicitly accuse them of Laziness too. But however I think we may justly enough apply, with a little variation, to our present purpose, that true saying of *Seneca, Multi ad Sapientiam perveniſſent, niſi &c.* and affirm, that many had attain'd to a greater knowledge and command of Nature, if they had not preſum'd that what is arriv'd at already, is much greater and more conſiderable than indeed it is; eſpecially in comparison of what is ſtill behind, and yet attainable: and therefore I think it not fit to ſuppreſs the Conſiderations I was about to mention, ſince the diſplaying them may perhaps do you and others Service, if they rouze up your Curioſity by ſhewing how much it has been defective, and it (which they ought to do) they encourage it alſo, by ſhewing You how much of Nature undiscover'd there yet remains, to Recompenſe as well as Exerciſe your Induſtrie.

But because that of the Particulars, whereby our Paradox may be confirm'd, there are divers that properly belong to the next ensuing Essay, the Proofs that we shall mention in this Discourse, though I hope they will appear sufficient alone, will yet be much strengthened both as to number and weight, if you please to adde to them those Instances to be mentioned in the next Discourse that may be conveniently referr'd to This. In which I shall therefore insist but upon V. general Considerations; In all which I hope You will not forget that I have already taken it for a Supposition, which I doubt not of your granting me, That the Usefulness of the works of Nature to us depends chiefly upon the knowledg we have of their Properties and other Attributes, and consequently, that the more we know of these, the greater Use we are like to be able to make of those Physical things, (and on the contrary.) And therefore that ought to be look'd on as an Use of a Physical thing, even though not immediately practical, that helps us to make Discoveries of things that probably may prove so.

The 1. Section.

AND I consider in the first place, *That there are very few of the Works of Nature that have been sufficiently consider'd, and are thoroughly known*, even as to those Qualities and other Attributes of this and that Body (or other Physical thing) which belong properly to it, and are not thought to be so relative to other Bodies. 'Tis not onely in the Terrestrial Globe, but in almost every Body to be met with in it, that there may be a kind of *Terra incognita*, or undetected part, whose Discovery is reserv'd for our further Industry.

This will appear the less improbable, if we consider these two things; whereof the one is, that there are divers ways of investigating the Attributes of Bodies, as Chymical, Optical,

Optical, Statical, &c. which being Artificial, and requiring Skill, and Industry, and Instruments, there are very few men that have had the Curiosity and Ability to examine them after these several ways: Without which nevertheless, divers other Attributes, some of which probably are capable of useful Applications, are not like to be discover'd. To the Proof of which, if it were needful, a multitude of Passages in these present Essays, as well as in our other Writings, might be easily referr'd.

I shall therefore rather insist a little on the 2^d of the two particulars lately mentioned. For it will easily appear not unlikely, that there should be many things undiscover'd in the other Works of Nature, when there are so even in those obvious and familiar Objects that men are frequently conversant with, and have occasion to take Notice of; nay even in those Noblest of meer Corporeal things, our own Bodies, whose Structure does so much merit our Curiosity, and of which it so highly concerns no less than our Healths and Lives, that we have an Accurate knowledg. How many new Discoveries have been made in the present Age, beyond what the Industry of the Physicians and Philosophers for above 2000 years has been able to take notice of? Witness the Circulation of the Blood, the *Acellian*, *Pecquetian*, and *Bartholinian* Vessels; to which may be added the *Ductus Pancreaticus*, and to which I doubt not will be added divers other Discoveries, to recompense the Industrie of the Anatomists of this inquisitive Age.

In so familiar Bodies as Eggs and Chicken are, which so many thousand persons do dailey see and handle, and perhaps eat, though many Ages since even *Aristotle* was solicitous about the History of them, concerning which he has deliver'd divers not inconsiderable particulars; yet there has been little within these few years so much undiscover'd, that whilst men were hotly disputing whether the Chick was first form'd
of

of the Yolk or the White, our excellent *Harvey* made it evident (which our own Observations have confirm'd to us) that it is made of neither, nor yet of the Tredle, (as some modern Observers have taught,) but of the *Cicatricula* or Speck that appears on the Coat of the Yolk.

Who would imagine, that in a Body so familiar, and so often treated of by Philosophers, as Snow, Mankind should for so many Ages take no notice of a thing so obvious as the Figure of it frequently is; and yet *Kepler* is by a very learned Writer acknowledg'd to have been the first, that acquainted the World with the Sexangular figure (as tis wont to be call'd) of Snow, in a Discourse by him publisht on that Subject; and though I find mention made of it in *Olaus Magnus*, and have observ'd it so often (but not constantly in the same shape,) especially about the beginning of the season of Snow, that I cannot but admire, men should not have very early heeded so obvious a *Phænomenon*, yet I find not the Discovery of it had been made so much as an Age agoe.

As many Ages as Vinegar has been one of the commonest Liquors in the World, yet that it oftentimes abounds with Shoals of Living Creatures, that move, and in the Microscope look like little Eels, was lookt upon but few Years since as so new a Discovery, that when, as I formerly noted, I first propos'd it here in *England* to divers very Learned Men and *Virtuosi*, as a thing to be seen even without the help of a Magnifying Glass, they took it to be a deception of my Eyes, till their own assur'd them of the contrary.

That the Milky Way, though consisting of innumerable Stars, should for 2000 Years pass for a Meteor, the inconspicuousness of those Stars keeps me from much admiring. And for the same Reason I wonder not, that the men that liv'd before *Galilæo*, reckon'd no more than 7 Planets, or suspected not that *Venus* her self is sometimes Horn'd, and has her Full and Wane as the Moon. Though these Instances

stances may serve to confirm what I lately told You, That many of the Attributes of Bodies are not like to have been discover'd by those that imploy'd not Artificial Helps. But what may we not expect that Mankind may overlook, when the Sun himself, which is not onely the most conspicuous Body in the World, but that by whose Light we see all the Others, may have vast and dark Bodies (perhaps bigger than *Europe* or *Asia*) frequently enough generated and destroy'd upon him, or about him; and men, without excepting Astronomers, never took notice of it, till of late Years the Excellent *Galileo*, or the industrious Jesuite *Scheiner*, informed the World of them. And though I grant that they discover'd them by the help of Telescopes, (Instruments unknown to the Ancients,) yet if Men had been as watchful, as the Noblenes and Conspicuousnes of the Object would make one expect, they might have discover'd some Spots at least without those Helps. For I find by an Italian Letter of *Galileo's*, that some Curious persons of his Acquaintance, after his Discoveries had awaken'd them, descry'd and discover'd some of those Solar Spots with their naked Eyes unassisted by his Tubes.

It may belong to this first Section of our present Essay to take notice, that one Account, on which we may reasonably suppose men to be ignorant of the Uses even of those things wherewith they think themselves well acquainted, may be, that the bare difference of Climates, and of Places, may even in such Bodies as we familiarly converse with, beget such new Relations betwixt them, as may endow them with Qualities, and fit them for Uses we dream not of.

I will not here mention the differing Qualities that Bodies, vulgarly referr'd to the same *species* of Plants, Animals, and other Bodies in almost all Countries, are endow'd with in some Countries; (as that Spiders are not venomous in *Ireland*, and *Irish* Wood in general, if the received Tradition be

be true, has an hostile faculty against venomous Creatures,) because the insisting on this Subject would take up too much room in this place, and is reserv'd for another; and therefore Ile onely adde a Couple of Instances, the One to manifest what difference of Climates may do, and the Other to shew the unexpected Influence of difference of Places, though perhaps in the same Climate.

The First of these Examples is afforded us by Water and Ice; for those that live in those warmer Regions where it never freezes, and who have divers of them derided the Relations of what happens in gelid Climates as ridiculous, in probability would never dream, that it could be a familiar use of a Liquor they were so well acquainted with as Water, to be broken or beaten in Mortars like a dry Body, and carried in Carts or Wheel-Barrows from place to place, and kept all the Year in that form, to make other Water intensely cold in the greatest heats of Summer. And even amongst us, those that have not been very inquisitive, can scarce imagine that one of the uses of Water should be to serve for High-Wayes, whereon Armies may march for divers daies together, with all their Carriages and Artillery, and whereon they encamp and fight Battels with as much assurance as on the firm Land; and yet those that have been in *Russia*, and the neighbouring Northern Countries, assure us, that during the Winter when the Rivers are frozen over, they usually take great Journeys on them, and oftentimes rather than in Summers, and choose that rigorous Season, which allows them to march every where without sinking into the Ground, to prosecute their Wars in.

The Second of the forementioned Instances we are supplied with by the Declination of the Magnetick Needle from the true North and South points, and the variation of that Declination. For though the Loadstone were highly admired, as well by Philosophers and Mathematicians,

as the Vulgar; and though since the great and happy use of it to Navigation has been generally known, men have been upon several accounts invited to consider it with a peculiar attention and regard, yet that in some places the Magnetick Needle does not point directly, perhaps not by a great many degrees, at the Pole, as in others it does, is no ancient Observation, since tis ascrib'd to *Sebastian Cabot*; and it appears by the Writings of our famous Countrey-man *Gilbert* Gilbert de Ma, guete lib. 1. c. 1. himself, *That it must be some body that liv'd since he wror, that must have the honour of being allow'd the first Observer of that strange and unexpected *Phenomenon*, *That oftentimes in the self same place, the declination of the Needle towards the East or West, does in process of time considerably alter.* * See the same *Gilbert lib. 4. cap. 3.* Which Discovery I could confirm by comparing some Observations I have had Opportunity to make, with those recorded by some modern Authors.

And as the same kind of Bodies may have differing Qualities, and consequently Uses in differing places; so they may have, if examin'd or imploy'd at differing times, comprising under that name, together with the 4 Seasons of the Year, those peculiar Seasons or Periods of Time, to which some signal Change of Qualities or state in particular Bodies do belong.

The Mutations, upon the account of Time, which I am here speaking of, are not those that are obvious to every Eye, such as the differing Qualities of Fruit green and ripe, or the Degeneration of Wine into Vinegar, but such as are not vulgarly taken notice of, and require either Skill or Curiosity, or both, in the Observer; and of these a few Instances will suffice for a Taste.

When common Urine either is freshly made, or has not long been kept, the volatile and pungent Salt is so clogg'd with other particles wherewith tis associated, that usually, to obtain it, one must evaporate or distill away near 8 or 9 parts

of 10 of the Liquor, and then at length give a not inconsiderable Heat to force up the Last: but though the Tradesmen that deal in Urine do commonly overlook the difference; yet if the crude Liquor be kept 6 or 7 Weeks, though not near the Fire, the Saline and Noble parts will have so extricated themselves, that a very gentle Heat will make them ascend, and leave behind them that Phlegm that formerly would have preceded them.

That the *Thames* Water, which our Navigators are wont to take with them in long Voyages, after a while, if they sail into hot Climates, stincks very often too offensively to be potable, that, which happens usually to Water which is vulgarly observ'd to putrefie by long standing, will easily perswade us; and yet tis found, that this Water, by being kept long enough in the same Vessels, though it be in the same or even in an hotter Climate, will at length loose its Stinck, and grow potable again; as I have, upon Enquiry purposely made, been assur'd, not onely by the vulgar Tradition, but by two very inquisitive Persons upon their own knowledge: the one having particularly observ'd it, sayling betwixt *Europe* and *Africa*, and the other in a Voyage to, and from *America*. And I the rather mention this, because I am very credibly inform'd, that there are divers other waters, that have this faculty of recovering after Putrefaction, which is suppos'd to be peculiar to the water of the *Thames*.

And, if I much mistake not, one or both of these very Persons nam'd another River to me, with an affirmation of its having the same power of Self-Recovery. And having held some Curiosity to try Experiments, how Pump-water, or the like rough Water, as they call them, that would not bear Soap, may be help'd, an Industrious Person I employ'd assur'd me, That he met with Pump-waters, which after having stood a few dayes, without having any thing done to them, would bear Soap, which before they would not do.

Coriander

Coriander Seeds, being freshly gathered, have been observ'd to have so much Acrimony, that divers of the Ancient Physicians reckon them among Venemous Plants; and in Dispensatories they are usually prescrib'd to be prepar'd with Vinegar, or some other Corrective: whereas the more accurate Observers take notice, that within a competent time after the Seed is gathered, it looses of it self that excessive Acrimony that at first blemish'd it. And the like I find observ'd, by good Apothecaries, of the roots of Aron, which are mitigated by keeping, (and which some noted Physicians of my Acquaintance do little lesse magnifie to me than does *Quercetan* himself.)

[That Vegetables, what *known* way soever they are wont to be laid up, and *order'd*, do not afford, unlesse first reduc'd to Soot, any dry volatile Salt, like that of Animal Substances, I elswhere more particularly declare, and those that have had the Curiosity to try it will confirm; but yet by some Discourse I lately had with a very Ingenious person, and some subsequent Tryals made after a way I devis'd to examine distill'd Liquors, I was satisfied that there are divers Vegetables, and those very commonly growing here in *England*, which being gather'd and laid together at a certain Season, and distill'd also at a certain nick of time, will yeild, in stead of the Vinegar-like and other Liquors wont to be afforded by such Plants distill'd the common way, a volatile Spirit; which in Smell, Taste, and divers operations, as turning Syrup of Violets green, hissing with acid Spirits, &c. resembles the volatile Spirits and Salts of Animal substances; and, which I doubt not but You will wonder at, this great Change, whose Secret I wish I durst teach You, is effected without the help of any Additament.]

And that You may not think that tis onely in Vegetable & Animal Substances, that are commonly of a mere loose or alterable Texture, that the trying things at one time

rather than another may be very considerable, I will add a couple of Instances even in Mineral Bodies.

It is a Chymical Complaint, even of the Curious and Experienced, that though Authors teach us to make the Salt of violently distill'd or calcin'd Vitriol, by forthwith taking the *Caput mortuum*, (from which all the Oyl has been by the violence of Fire forced out,) and extracting the Saline part by affusions of Water; yet those that make exact tryals of it find, that when the dark red Mass of Powder is newly taken out of the Vessels, tis so totally robb'd of its Saline particles, that no Affusion of Water will at all obtain from it the expected Salt. Notwithstanding which, having purposely enquir'd of some, that distill great quantities of Oyl of Vitriol, whether or no, when they had made an end of one Distillation, if they lay by the *Caput mortuum* for a pretty while in the Air, they could not find it impregnated enough with new Saline particles, to be fit to yeild more Menstruum, and be worth another Distillation? I was answer'd in the Affirmative, provided that (as I mention'd in the state of the Case) there were a competent time interpos'd between the former and the latter Distillations. (The reason which, according to my Tryals and Conjectures, may be assign'd of this odd *Phenomenon*, belongs not to this place, but You will hereafter meet with it in another.)

The second Instance I promis'd You, is afforded me by Stones; for there are, and not far from this place, Quarries of solid and useful Stone, which is employ'd about some stately Buildings I have seen, and which yet is of such a Nature, wherein divers other sorts of Stone are said to resemble it, That though being digg'd at a certain Season of the Year, it proves good and durable, as in those Structures newly mentioned; yet employ'd at a wrong time it makes but ruinous Buildings, as even the chief of those Persons, whose Profession makes him more conversant with it, has himself
acknow-

acknowledg'd to me to have been found by sad Experience. But concerning this Observation, You may expect to meet elsewhere with a further account.

And though Time and Place be two of the principal, yet they are not the onely Circumstances, whose Variations may make some such Attributes discover'd in Natural Things, as are not usually heeded; of which I shall mention but a Couple of Instances, because they may serve to shew You, That such Circumstances as are thought the slightest, may afford new Uses even of Solid and lasting Bodies. Skillful Artificers, that grind Optical Glasses for Tubes, have complain'd to me, That oftentimes the convex Glasses they fashion, will prove Veiny, and consequently, after all their labour, of little value; and yet they are not able to discover these unwelcome Veins in the Glass, by the most careful viewing it against the Light, till they have spent a pretty deal of time about working of it, and even then they are unable to descry these Blemishes, if they hold the Glass at an ordinary distance from the Eye, but they are oblig'd to remove it a great way (perhaps 6 or 7 foot) farther, so much may an increase of Distance become serviceable, even where one would expect the quite Contrary.

But probably You will look upon Posture as a slighter Circumstance than Distance it self, and yet Dr *Gilbert* has observ'd, and I have found it true by many Tryals, That long Irons, as the Bars of Windows, that have stood upright for a great while, do, by that perpendicular Posture, acquire a Verticity or Magnetick virtue, as having acquir'd Magnetick Poles. So that if You apply the Needle of a Dial (which I mention as the readiest way of Tryal) to the lower part of the Bar, it will draw the South end of the Needle; whereas the upper Extream of the Barr will seem to drive away that end, and will draw the Northern.

But here I must not forget to take notice, that I can scarce think

think Men will be able to know all the Properties and Uses even of familiar Bodies and other things, till they have Mathematically consider'd them; there being several Attributes belonging even to such things, which a Naturalist, though Curious, will probably never find out, unlesse he be both acquainted with Mathematical Disciplines, and have the Curiosity to apply them to Physical Subjects. And though in other Essays of this Book divers things are deliver'd, that do directly enough tend to manifest what I have now said; yet tis of such importance, that Naturalists should be thoroughly perswaded of a Truth, that may be so much more useful than tis yet generally admitted, that I am content to inculcate it by setting down here a few Instances of somewhat a differing sort from those elsewhere delivered, and more appropriated to the present subject of our Discourse.

You will not doubt, but that ever since the first Ages of the World, the majority of Men have had some occasion or other to see Bodies swing; and yet till *Galileo* (for he is generally believ'd the Discoverer) took notice of the Vibrations with a Mathematical Eye, men knew not this property of Swinging Bodies, That the greater and smaller Arches were, as to Sense, equitemporaneous; from which Discovery have been deriv'd several Practices of good Use, some of which have been already mentioned in these Essays.

That Water, running out at a Hole made in the sides near the bottom of the Vessel, makes a Parabolical line, or one that neer resembles it, and that in such effluxions of water there is a determinate proportion assignable betwixt the perpendicular height of the Liquor, and the Diameter of the Hole, whereby the Velocity and Quantity of Water that would run out, may be computed; has not been, that I know of, taken notice of, till the Observations of the above nam'd *Galileo* and the diligent *Mersennus* (to which we may elsewhere add some of our own) have endeavour'd to define those matters.

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As constantly as we have occasion to take notice of Air, and Water, and Glass, yet the Curiosity of our modern Masters of Opticks has observ'd many things touching the Refraction of the beams of Light, made in those mediums in differing Quantities, and To and From the Perpendicular, not to say any thing of the Equality, of the Angles of Incidence, and of Reflection made on the Surface of still Water, unheeded by those that are not vers'd in Opticks: The drops of Dew, that hang in numberless multitudes upon the Grass and Leaves, are things that every Eye has been invited to take notice of, by the Orient colours the Sun is wont to make them afford us; but till the Excellent *Des Cartes*, Met. cor. am. cap. 8. contemplating them with a more Critical Eye, found, That in such a determinate Angle made at the Spectator's Eye, between the ray of Light coming from a certain part of the Drop, and the imaginary strait Line reaching from the Eye to the Sun's Center, the Drop appear'd red, and in another determinate Angle exhibited Yellow, Blew, and other Colours, and at other Angles shewed no Colour at all; the World ignor'd a considerable property of Spherical Diaphanums irradiated by the Sun, and seems not to have dreamt of a neat *Hypothesis*, with which some Ingenious mens Minds are no lesse taken, than their Eyes are with those vivid colours of the Rainbow, which it pretends to give a clear account of. And though we daily see pieces of Wood and Timber broken by the weight of over heavy Bodies, yet till the often nam'd, and still to be commended *Galileo* apply'd Geometry and the Doctrine of Proportions to matters of this kind, the resistance of Solid bodies to be broken by Weight (whether their own, or that of other Bodies) seems not to have been so much as suspected to be reducible to such an Estimate, as he and others have brought it to. And a *Virtuoso* of my Acquaintance, (for whom *Mersennus* laid the way) in a Musical Instrument, that I have with pleasure

sure heard him play on, can observe a property of Metals that Chymists thought not of, namely, that equal Wire-strings made of differing Metals, and having a due Tension, will yeild Sounds, differing as to Sharpnes by determinate Musical Notes, or the Divisions of them. And to these I might add divers other Remarks of *Mersennus* and *Galileo* about the force of Guns, (which were found to increase with their Length but till such a number of Feet, beyond which the Length did but lessen it,) and the Parabolical line in which Bullets (that are thought of all other Bodies to move the straitest) are said to move; and I know not how many other Mathematical Attributes (if I may so call them) of Natural things, that Geometricians, Astronomers, Engineers, &c. have already observ'd, might be here added, but that I think it sufficient to subjoyn one Instance more, that may well serve to keep us from imagining, that even the most familiar Objects in the World, and that seem likely to afford the least Discoveries, have been sufficiently consider'd. For how few *Phænomena* in Nature are there, that occur to us more frequently than the falling of heavy Bodies? and yet though the Ancients and *Aristotle* himself took notice, that there was an Acceleration of Descent in falling Bodies, yet we find not that any so much as fairly attempted to determine that acquir'd Velocity, till *Galileo's* Observations reduc'd it to the Proportion mentioned in some of the former Essays, wherein most of the following Mathematicians (for I have scarce met with two Dissenters) have acquiesc'd; and whereby in the VIIIth Essay we endeavoured to measure Heights and Depths without Geometrical Instruments. In a word, till Geometry, Mechanicks, Opticks, and the like Disciplines be more generally and skilfully applied to Physical things, I cannot think otherwise than that many of the Attributes and Applications of them will remain unknown; there being doubtles many Properties and Uses of Natural things,

things that are not like to be observed by those men, though otherwise never so learned, that are strangers to the Mathematicks.

And as I have hitherto observ'd of *Bodies*, so I shall venture to add of *Qualities*, and divers other Natural things, that even those, that are very familiar, may have Attributes and Uses, which the Generality of Men, without excepting those that are otherwise Learned, are not wont to take any notice of.

That Black bodies (for Instance) as such, are much more strongly and easily warm'd by the Sun beams than White ones, nay (though the disparity be not so great) than Bodies of any light Colour, *ceteris paribus*, is perhaps more than even You have taken notice of: and yet I shall hereafter have occasion to prove it by divers Instances, and You may easily try it, either by exposing for some time to the Summer-Sun a White Glove and a Black, or a couple of Eggs, whereof one is Ink'd, or otherwise Black'd, all over.

Cold is one of the most familiar Qualities Men have to deal with, and though they otherwise are not wont to expect much from it, yet least of all would they expect that it should, contrary to the receiv'd Definition of it, which is, *congregare tam Heterogenea quàm Homogenea*, that it should, I say, perform the office of Heat in Spirit of Wine, nay and in presenting us ardent Spirits from Beer and other Liquors inferior to Wine; and yet, not to mention *Paracelsus's* Process of making the Essence of Wine by freezing all the Flegm, we have the repeated Experiments of Navigators into the Frigid Zone, who assure us, that not oaly from Wine, but from Beer, by the Congelation of the Aqueous parts, there may be separated or obtain'd a Liquor strong, hot, and Spirituous, almost like *Aqua vita*.

And even in our temperate Climate some odd Separations may be made by Cold; for, not to anticipate those tri-

als of mine that belong to other Papers, there may, by such Cold as we have here, be made a Separation in Oyl, of a Liquor much finer and more Spirituous than the rest; for I know an Eminent Artificer, who kept it as a choice Secret to resort (as himself confest to me he did) in hard Frosts to the great Jarrs of Oyl, where he often found greater or lesser Cracks or Chinks in the congeal'd part of the Oyl, in which Crannies was contain'd an unfrozen Liquor, that appear'd thinner and finer than common Oyl, and was much better than it to preserve things from rusting; (as perhaps having left many of its Saline parts in the Concreted Oyl,) and for that purpose was much priz'd not onely by him, but by some Watchmakers, that were made acquainted with the virtue of it.

But twere tedious to insist on all the Instances that may be brought, of the Applications that may be made of Colour, Sound, Levity, Springines, Fermentation, and even Putrefaction; and twould be not onely tedious, but almost endless to prosecute those Instances that might be afforded by other more general and operative states and faculties of Bodies. For not onely Motion and Rest, Fluidity and Firmness, Gravity, and the like, have a more universal Influence on Natural things, than even Philosophers are wont to take notice of: but those lesse Catholick Affections of Matter, that are reckon'd among but particular Qualities, such as Gravity, and Heat, may have so diffus'd an Influence, and be applicable to so many differing purposes, that I doubt whether all the Uses of that particular degree or Pitch of Heat that reigns in Fire, will have all its Uses discovered, before the last great Fire shall dissolve the Frame of Nature.

Nor must I pretermitt one consideration more, that belongs to my present Subject, which is, that probably many more Qualities (or other Attributes) would be taken notice of, even in those Natural things that are reckon'd among the
most

most known, if Men did not want a measure of Curiosity that might justly be expected. For I speak not here of Curiosity in general, (which I doubt not would make far more numerous Discoveries, than were necessary to justify my present Discourse,) but I onely speak of such a Curiosity about the things of Nature we familiarly converse with, as we could scarce want, if it were not out of Laziness, or a prejudicate Opinion, that makes us take that for granted, that we should find to be quite otherwise, if we did not choose rather to *presume* than to *try*.

Thus that falling Bodies, the heavier they are, the faster in proportion they fall, has been a receiv'd Opinion in the Schools since *Aristotle's* time, and has kept the Equivelocity (as to Sense at least) of Bodies of very differing bulks and Weights falling from moderate Heights (such as surpass not ordinary Towers and Sreeples) from being taken notice of, till of late Inquisitive men by Experiments found it out.

That Water by Glaciation is reduc'd into a lesser Room, has been and is still the opinion not onely of the Vulgar, but of the generality of Learned men; and yet that Water is not condens'd but expanded by freezing, he that will congele that Liquor in vessels strong enough, may easily find by tryal. And the floating of Ice upon Water, and the Bubbles that are usually to be observed in it, may alone to suffice to make a considering man distrust the vulgar Opinion.

That the common Air we breath and live in, is a Body endowed with positive Levity, has been for many Ages, and continues to be almost universally believed; and yet if men had the Curiosity to examine this Supposition by one or other of those several ways, by which the Gravity or Levity of the Air may be discovered, they would quickly find that tis not devoid of Weight. And even so slight a way as the condensing the Air in a blown Bladder, by tying a String something strong about the middle of it, may bear witness

to what we say. For though we should oppose, as some have lately done, That in such cases the Air is not in its Natural State, but condens'd; besides, that is an Objection, to which all the Expedients of weighing Air are no way liable, it makes rather against the Objectors, than the Conclusion against which they urge it; since, if the Particles of the Air be really light, the filling the Bladder the fuller of them ought to make it rather lighter than heavier.

That greater and lesser Sounds do, as to Sense, move with an equal Swiftneſs, is that whole Contrary is taken for granted; and the more excuſably, becauſe tis evident and confeſt, that great and ſmall Sounds do not move equally far: and yet that this Equivelocity of Sounds has been made out by the late Observations of the diligent *Merſennus*, and others, you may remember to have been delivered in a * foregoing Eſſay, where I alſo endeavour'd to ſhew, That this property of Sounds is not unappliable to Humane Uſes.

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That the Loadſtone, which by immediate contact will rake up Iron, ſhould have ſo ſtrange a Property as to take up far more when a Cap, or conveniently ſhap'd piece of Steel is interpos'd betwixt it and the Body to be rais'd, is a thing ſo unlikely, that though the Ancients knew and much admir'd the Attractive Virtue of the Loadſtone, yet they ſeem'd not to have ſuſpected it enough to vouchſafe it a Trial: and yet ſince *Gilberts* Writings came abroad, he muſt be a great Novice in Magnetical Affairs, that either ignores or doubts it. But I muſt not do any more than touch upon Magnetical Experiments, ſince they alone would afford me ſo many Truths (which the generality of men would not have thought likely enough to be worth trying) that to enumerate them, though it might convince Your Underſtanding, would I fear *exerciſe* Your Patience.

That tis the property of unſlak'd Lime to grow hot by *Antiperiſtaſis*, upon the pouring on of cold Water, and other

ther cold Liquors, and consequently not to grow hot upon the Affusion of Liquors that are not Cold, is not onely generally beleived both by Learn'd and Unlearned, but this property of Lime has been imployed as an Argument to prove other Matters, as well by divers of the new Philosophers, as by many of them that imbrace the old *Aristotelian* Principles: whereas I doubt not but a little Tryal might easily disabuse them: for by the Affusion of divers Liquors actually warm, I have made Lime flake with its wonted violence, if not with a greater. And in other Liquors actually Cold like unheated Water, and one or two of them far more thin or subtle than It, I have kept Lime long without flaking, and without imparting to the ambient Liquor any sensible Heat. The Quality of these Instances makes me think it needless to increase their Number, since we can scarce with a greater inducement to expect, that many new Attributes may be discovered in the works of Nature, if mens Curiosity were duely set on work to make Tryals, than that divers have been found out that seem'd so unlikely, that men thought it would be in vain to try them.

To these several sorts of Instances, that have hitherto been reduc'd to our first Consideration, might well be added, That Bodies which have the same Denomination, and from whence men are therefore wont to expect the same, and but the same, Operations and Uses, may yet have peculiar ones, and some of them very differing from those of the Generality of other Bodies that bear the same name. But Examples of this kind will more conveniently be mentioned in the last Essay: and least this should swell too much, dismissing this present Consideration, we will advance to the Next.

THE II. SECTION.

I Consider in the second place, That the Faculties and Qualities of Things being (for the most part) but certain Relations, either to one another, (as between a Lock and a Key;) or to Men, as the Qualities of External things referr'd to our Bodies, (and especially to the Organs of Sense,) when other Things, whereto These may be related, are better known, many of These with which we are now more acquainted, may appear to have useful Qualities not yet taken notice of.

I shall elsewhere, *Pyrophilus*, have occasion to shew You more fully on what Grounds, as well as in what sense it is, that I take the most of the *Qualities* of Natural Bodies to be but *Relative Things*. To our present purpose it may suffice to adumbrate my Meaning by the newly hinted Example of a Lock and a Key, where, *as* that which we consider in a Key, as the power or facultie of Opening or Shutting supposes and depends upon the Lock whereto it corresponds; so most of those Powers & other Attributes that we call Qualities in Bodies, depend so much upon the Structure or Constitutions of other Bodies that are dispos'd or indispos'd to be acted on by them, that if there were no such Objects in the World, those Qualities, in the Bodies that are said to be endow'd with them, would be but Aptitudes to work such Effects, in case convenient Objects were not wanting. As if there were no Lock in the World, a Key would be but a piece of Iron of such a determinate Size and Shape. And this Comparison I the rather imploy, because it may be further applied to our present Discourse. For *as* if some barbarous *American* should among other pieces of Shipwrack, thrown by the Sea upon the Shore, light upon a Key of a Cabinet, he would probably look on it as a piece of Iron, fit onely for

for the inconsiderable Uses of any other piece of Iron made much broader at each end than in the middle; but, having never seen a Lock, would never dream that this piece of Iron had a faculty to secure or give access to all that is contain'd in some well furnish'd Chest or rich Cabinet: *So* there is many a thing that seems to us useles, whilst we look upon it only in it self, which will perhaps hereafter prove highly useful, when we shall light upon some other Bodies peculiarly fitted to act upon it, or receive impressiions from it. But this will be better apprehended by the following Instances.

Though Iron be so common a Body as it is, and its Uses are very many, and have been known as long as since *Adam's* time, yet all those differing Bodies, on which men of all sorts imploy'd it to work, and all those various wayes whereby Chymists, Physicians, and Mineralists have wrought on it during some thousands of Years, did never discover to man one of its noblest and usefulest Properties, which, for ought we know, was never found out till within these 3 or 4 Ages: for a Steel Needle, being applied to a Loadstone, manifested it self to be capable of constantly shewing the North and South in all Seas, in all Weathers, and in all times of the Day and Night to Navigators, who, by this Property, which depends upon the Relation that Iron has to one onely Stone, have been enabled to discover the New World, and enrich the Old with the Drugs and Treasures of it.

After all the vain Attempts that even subtle Chymists have made to arrest the Fluidity of Quick-silver, the knowingst Persons that have medled with that Mineral, and especially if they have observ'd that the keenest Frosts, that are capable of freezing even *Aqua vita*, are unable to congele it, have been very much indispos'd to reckon an easie Coagulableness amongst its Qualities; and yet we see, that though the Mixture of no other known Body will disclose its having any such Affection, yet the Vapor of melted Lead will sometimes

times (for that Experiment will not alwaies succeed) reduce Quick-silver even in its Mass into a consistent and somewhat tough and hard Body.

Vinegar being a Liquor, that has been generally known and us'd for somethousands of Years, men have imploy'd it upon great variety of Bodies, and to very many Uses, but especially to communicate a Sowerness to the things where-with twas mingled; but when it came (probably by chance) to be applied to the dissolving of Lead calcin'd or crude, it manifested that it had a faculty to exhibit a more than Saccharine Sweetnes, which, for ought I know, it exhibits with that Metal onely; for I have not yet known crude Vinegar dissolve Tin though Calcin'd, and though by a slight Artifice, elsewhere mentioned, we have been able to make strong Spirit of Vinegar dissolve the *Calx* of *Jupiter*, yet was the Solution far differing from, and inferior to, the Taste of the Solution of Lead newly mentioned.

Spirit of Urine is a Liquor that has been long known to Chymists, and might reasonably be lookt upon as likely to be a good Menstruum for several Bodies: but tis not probable, that after it had been imployed to dissolve divers compact Bodies, it should be suspected, that it would coagulate so thin, light, and fugitive a Body as Spirit of Wine it self: and yet we have often (as there will be hereafter divers occasions to relate) tryed, that if both Liquors be sufficiently pure and dephlegm'd, they will afford that strange Snow-white Concretion that *Helmont* calls his *Offa alba*; which, however by his Followers ascrib'd to him as the Inventor, I find mentioned in ancienter Books than his: and I remember that even *Raymond Lully* relates, with what wonder he first saw this Experiment (which indeed is considerable) perform'd.

And as the Spirit of Urine has such an odd Property, when it meets with ardent Spirits dephlegmed; so the Spirituous
parts

parts of Urine, without being separated from the rest, have a faculty that one may yet lesse expect, if they be duely employed, to operate upon Musk: as I have had the opportunity to inform my self by inquiry of a Scholar, who lived in *China*, and affirm'd himself to have divers times seen Musk made. For this Person answered me, that he had observ'd it to be the Practice of others, and had made Tryal of it himself in those Eastern parts, That the Musk being made up, and put into Cods or Bags made of the skin of the same Animal, (in which form I have received Presents of Musk sent me from the *Indies*) they do either before or after hang it in a house of Office, so as it may, without touching the grosser Bodies, receive the fetid Exhalations of that Nasty place; by which Urinons Steams, which tis expos'd to for some dayes, the lesse Active or more immers'd Scent is, as it were, call'd out, and excited or heightned. And I found by farther Enquiry of the same Person, that having carried Musk from those Eastern Regions, where tis made, to other and remote parts of the same *Indies*, he found, That by the length of the Voyage by Sea his Musk had very much lost its strength, which he afterwards restor'd to it by following the Advice of some skillful Persons, according to which he tyed the Musk close in a Bladder, wherein having prickt many little Holes with a Needle, he hung it up for some dayes in such a stinking place as has been newly mentioned. Whereto agrees very well what I have read in a late Eminent Physician of *Rome*, (where the Art of Perfuming is very much cultivated) who communicates it as the chief Secret practic'd by the Perfumers there, for recovering the Scent of decayed Musk, That it be kept for a competent time in Linnen well moistned with rank Urine.

The uses of *Gesso* (as the *Spaniards* and *Italians* call it) or *Gypsum*, are numerous enough in the Shops of Stone-cutters, Moulders in Plaister or Wax, and divers other Artificers;

but one would scarce suspect, that besides the various uses these Tradesmen put it to, it should have one so very differing from them, as to be an excellent Medicine, if I may so call it, for Wine: and yet that they use great store of it about those Choice ones that comes to us from the *Canaries*, is a noted Tradition among those that deal in in that sort of Liquor, and has been confirm'd to me by an Eminent Wine-Merchant, that liv'd several Years in those Islands. And that about *Malaga* they put a good proportion of it into the juice of their Grapes, when they tun it up, is affirm'd to me by a Curious Eye-witness, who was there in Vintage time, and of whom I purposely inquir'd about it.

Though Silver be so Noble a Metal, and so much known and us'd, that twas the Price of things as early as *Abraham's* time; yet one very fine use of it has been known, but since the Art of Annealing upon Glasse came to be practis'd. For among other Experiments of this Art we find, that prepared Silver (and I have sometimes done it pretty well with the crude Metal) being as it were burnt upon a Plate of Glasse, will tinge it with a fine Yellow or Golden colour: There are also divers Mineral Earths, and other course Files, of use in this Art, which, by the help of the Fire, makes them impart colours to Glasse, both transparent, and sometimes very differing from those of the Bodies themselves, as I may elsewhere have occasion to specify. In the mean time give me leave to name this Reflection upon the Art of Painting, That tis very hard for us to be sure that we know so much, as all the several sorts of Uses that may be made of the particular Bodies we converse with, since upon the invention of a new Art or Trade, of which we know not how many remain yet to be found out, divers Uses and Applications of Bodies come to be disclos'd, that were never suspected before.

The use of Lyes made with common Ashes to wash Lin-
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nen, has render'd them for these many Ages very familiar: But though their Effects on the other Bodies, upon which they have been employed, seem'd not to have any affinity with what I am going to mention; yet when a strong Lixivium is applied to Syrup of Violets, (which is also a very known Liquor) to which it has a peculiar Relation, it will then immediately change the colour of that Syrup from a Blew to a perfect Green, and so it will the Violet leaves crush'd on a piece of White Paper, without the help of Sugar, or any Preparation.

Redness, though a Colour as obvious as most others, and to the generality of men very pleasing, however it hath no offensive property in reference to other Animals, familiarly known amongst us, (at least that we have taken notice of:) yet being presented to the Eyes of Turkey-Cocks, it has such an incongruity with them, that oftentimes tis observed to make them very angry, as far as can be judg'd by the tokens of being displeased, it produces in them.

The Leaves of Oaks, that are such common things, and are not observed to have, in reference to any other Body, which Chance or Industry applies them to, any such Property as that I am about to name; these Leaves I say, if when fresh, they be immers'd in the water of Mineral Springs, impregnated with the subtle Corpuscles of Iron, I have several times found to turn the Liquor Blew or Black, according to the proportion and vigor of the two Ingredients.

One would not expect that so dark and black a Body as Char-coal, should be the main thing employed not onely to cleanse and brighten some Metals, but to procure a clearness, and give a Gloss to some transparent Bodies. And yet I learn'd from the makers of Mathematical Instruments, Gravers, and other Artificers, that the best way they have, and which I have seen them employ, to polish their Plates of Brass and Copper, (after they have been rubb'd clean with

powder'd Pumice stone) is with Char-coal, (which some of the more Curious burn a second time, and quench in appropriated Liquors,) as that, which both serves to fetch out the scratches of the Pumice-stone, and it self scours without scratching, and thereby polishes very smoothly. And by the same way they may cleanse and polish the Plates of Horn, of which they make Lanthorns, Drinking Cups, &c. To which, as to the Metalline Plates, a Gloss may be afterwards given with Tripoly.

Perhaps it will not be improper to take notice to You, *Pyroph.* in this place, That not onely the Nature of the Body to be wrought upon, but some peculiar Circumstances relating to it, may contribute to the Effects of such Experiments as those treated of in this Section. As for Example, one would not expect that Water, which is so apt to run out at the Chinks of wooden Vessels, should, without addition, become the fittest Instrument for closing them. And yet I have more than once found by Tryal, as I presume many Tradesmen have done, that when wooden Barrels or Firkins, and the like Vessels, by having been long kept too dry, come to have Clefts and Commisures, this inconvenience may be remedied by pouring Water into them. For though at first the Liquor quickly runs out again, yet by frequent affusions of it, the Wood, especially those Edges between which the Water runs out, becomes so softened and plump up, that the little Intervals or Chinks are, by the swelling of the neighbouring parts, clos'd up, and the Vessel becomes staunch.

And upon a like Reason seems to depend that odd Experiment, much talkt of by some of our Eminent English Seamen, who, for the hasty stopping of a Leak that is not too great, much commend the thrusting into it a piece of powder'd Peef; for this being much more salt than the Sea-water, that liquor pierces into the compact and (in great part) dry

dry Body, and by opening the Salts, and soaking into the Flesh, makes the swelling Beef expand it self, so as to bear strongly against the Edges of the broken Planks, and thereby hinders the Water from flowing into the Ship as it did before.

THE III. SECTION.

I Consider in the next place, That a Body in association with others may be made fit for new Uses, and some of them quite differing from those that were proper to it before.

This III. Consideration is, in some regards, of Affinity with the first, but yet is not the same, since in the former we consider the Power that one Body has to act upon another, or the disposition it hath to be acted upon by it; whereas now we consider the two Bodies or more, as being by Conjunction qualified to act on a third Body, or suffer from it, as one entire Concrete, upon the account of new and emergent Properties, accreuing to the Compound by the Association of the more simple Bodies that compose it.

You will meet with store of Instances, both in these Essays, and other of my Writings, easily applicable to the illustration of what is here delivered, and therefore it will suffice to name in this place the fewer.

He that takes notice how flexible a Metal Tin is, and how dead a noise it yeilds, will scarce dream that one of its Uses, and that none of the despicablest, should be to make another Metal, which is lesse yeilding, and has a lesse dead Sound than its self, not onely hard, but sonorous: and yet we see, that Bell-Metal, which, when cast into Bells, makes a hard Mixture that sounds so lowdly, is made principally, as has been already noted, by the addition of a certain proportion of Tin to Copper.

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In the common Experiment of making Ink, the Infusion or Decoction of Galls is yellowish, or reddish, and the Solution of Vitriol will, as the Concrete participates more of Iron or of Copper, be either green or blewish; but from the mixture of these two Liquors there will emerge an Inky Blackness.

That Oyl, that is a Body so mollifying and slippery, and whose Unctuousity makes its moisture so much more difficult to be wasted or destroyed than that of Water, Wine, or other not tenacious Liquors, should be one of the 2 or 3 main Ingredients, and the onely moist one of a hard and durable Cement, is that which probably You would very little expect from it: and yet, not to mention what Trials of that nature I have made, because I had not time to observe the full Event, a very ingenious man, much imploy'd about costly Water-works and Dams, assures me, That the best way he has to joyn together, and, if need be, piece and mend with a close and lasting Cement the Pipes, that are us'd for subterranean Aqueducts, that are long to hold running Water, is to take good Clay (such as Tobacco-pipes are made of,) and having dry'd it, and reduc'd it to very fine Powder, and mixt good store of short Flocks with it, beat it up very diligently with as much Linseed Oyl, as will serve to bring it to a stiff Past, almost like well kneaded Dow. This Past he fashions into Pipes of the length and bigness required, which though they will be long a drying in the Air, yet, when once thoroughly dry, are very stanch and lasting. And I remember, that before I learned this, having occasion to try divers Experiments about Cements, I chanc'd to meet with an ancient Artificer, imploy'd to keep in repair the Conduits that brought Water to *London*, and in exchange of a Lute or Cement that I taught him, he was forward to satisfy the Curiosity I had to know what Cement he imployed about so important a Work, and he assur'd me, That Oyl was

was one of the main Ingredients (and the onely Liquid one) he employed.

He that considers that Lead is one of the most opacous and flexible Bodies that the World affords us, will not easily imagine, that one of its Uses should be to make up about 3 parts of four of a Mixture transparent, and exceeding brittle; and yet this is easily perform'd by divers Chymists (and I elsewhere mention my having often done it) in making of calcin'd Lead, and powder'd Flints or Sand, a brittle and Diaphanous Composition, call'd by Spagyrist's *Vitrum Saturni*.

And this mention of Glass suggests to me another Instance, fit for my present purpose: for who would imagine that such a Body as the fix'd Salt of Chaly, which, as other Alkalyes, that take their Denomination from it, has a strong and fiery Taste, and is not onely readily dissoluble in Water, Wine, or any such liquor, but will in a short time, being but left in the Air, be reduc'd into a Liquor; who would expect, I say, that it should be of any Use, much less the Main of this Causick, and easily dissoluble Body, to be one of the two main Ingredients of Substance both perfectly insipid, and indissoluble, not onely in Water, Wine, &c. but even in *Aqua fortis*, *Aqua regia*, Spirit of Wine, Quick-silver, Spirit of Urine, and other Menstruums, some of them highly Corrosive, and others extremely subtle and piercing: and yet such a Mixture is usually afforded us in Glass, (especially the most durable sort of it) wherein, That there is actually a great proportion of Alchalizate Salt I confesse I doubted, till having purposely enquired of an Ingenious Master of a Glasse-house, how much Glass he usually obtained when he put in such a Quantity of Sand, I found by his Answer, That the Glass obtain'd was many Pounds in the hundred more than the Sand that was employ'd to make it, whence I gathered, (what he also affirm'd) That the Alcali did not onely seem

(as one might suspect) to promote the Fusion of the Sand, but does materially and plentifully concur with it to compose the Glass.

And whereas I intimated at the very beginning of this 3^d Section of this Essay, That Bodies, when associated, may be applied not onely to new Uses, but perhaps to some that are quite differing from those that belong to some of the respective Ingredients. This Observation may be made good by several Instances, and even by some that are very obvious, as well as by others that are not so familiar. For we may take notice, that though Oyl, and Tallow, and other such Unctuous bodies, be those that do grease and spot Linnen and Wollen Cloaths; yet those very Bodies, being skilfully associated with others, though with but a Lixiviate Salt and fair Water, do plentifully concur to the making up of Soap, by the Solution of which, Grease is readily wash'd out of Linnen Cloaths, and others besides those are also freed from the Spots of it. But divers other Instances applicable to this purpose, belonging more properly to the following part of this Essay, till we come thither it may suffice, that I illustrate and confirm what hath been propos'd by the single, but noble instance of *Aurum fulminans*. For though Salt of Tartar be a fixt Body, and of a fixing Quality, yet being skilfully associated with Gold dissolv'd in *Aqua Regis*, though that be thought the fixedst, not onely of Metals, but of Bodies, yet the Gold precipitated by this fixt and incombustible Salt, becomes so exceeding fugitive, that by a gentler heat than would kindle any known Body in the World, it is made to Fulminate like Gun-powder, (but many degrees more violent than it;) and (which you will also think strange) though *Sulphur* be a Body of so quick Accension as is obviously known, yet by an easie way (elsewhere to be taught You) of mixing those two onely, You may, as Tryal hath inform'd us, make it (which You will easily allow to be one of

of the unlikelyest uses of Sulphur) even by its being set on fire, to hinder the Accension of this so easily kindled Gold, which I have known thereby readily turn'd into a Medicine, that some cry up for excellently Diaphoretick, (though I doubt whether *Aurum fulminans* work not rather another way,) and which I remember I have (in a Crucible) kept long in the fire without losse.

I shall onely adde to this third Consideration this one particular, that is of too great moment to be pretermitted here, though it have been already in part taken notice of on another occasion, namely, That the Effects and Uses of Mixtures do not onely depend upon the nature of the Ingredients, but may be oftentimes much varied by their Proportion. And of this the Mineral, which at the Glass-houses they are well acquainted with, under the name of *Manganese*, will afford us a pertinent and considerable Instance. For though it be a coarse and dark Mineral it self, and though being added to the Materials of Glass in a fuller Proportion, it make the black Glasses that are sold in shops, yet not onely a moderate proportion of it is us'd to make Glass red, but which is more remarkable, a small and due proportion of it is commonly employed to make Glass the more clear and Diaphanous.

THE IV. SECTION.

IN the Fourth place I consider, That a Body, by a differing preparation or management, may be fit for new, and perhaps unthought of, Purposes. For the Qualities of Bodies depending for the most part upon the Texture of the small parts they are made up of, those wayes of ordering greater Bodies, which do either by Addition, Detraction, or Transposition of their Component Corpuscles, or by any two, or all of those wayes, make any notable Change of the former

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Texture of the Body, may introduce new Qualities, and thereby make it fit for diverse Uses, for which twas not proper before.

We see to how many several Uses Men, that were neither Philosophers nor Chymists, but for the the most part illiterate Tradesmen, have been able to put Iron, by but varying the visible Shape of certain Portions of it, and connecting some of them after a peculiar manner: as is obvious in the shops of Blacksmiths, Lock-Smiths. Gun-Smiths, Cutlers, Clock-makers, Iron-mongers, and others. But to give You a more Physical Instance in the same Metal, be pleased to take notice, how much a Change, made by a Natural Agent, the Fire, in the invisible Texture of Iron, does speedily alter it; when of the same Bar of Iron, by the help of Fire and Water, the Artificer makes harden'd Iron, and Iron of a temper fit for Drills, and Knives, and Springs, and I know not how many other Instruments, which require distinct Tempers in the Metal they are made of; that Temper which renders them fit for one use, leaving them unfit for another.

But we need not confine our selves to Instances, wherein no new Ingredient is added to, or taken from the Body to be alter'd; it being sufficient, that the Additament upon its own account do not bear so great a stroke in the Change produc'd, but that it be principally ascrib'd to the way of ordering the Body wrought upon; and speaking of the management of a Body in this Sense, (which is usual and proper enough,) I shall subjoin a few Instances, of the many I might adde, to make good our Proposition.

Though Paper be one of the commonest Bodies that we use, yet there are very few that imagine it is fit to be employ'd other waies than about Writing, or Printing, or wrapping up of other things, or about some such obvious piece of Service, without dreaming that Frames for Pictures, and divers
fine

fine pieces of Emboss'd work, with other Curious Moveables, may (as Trial has inform'd us) be made of it, after this or the like manner. First, soak a convenient quantity of whitish Paper, that is not fine, about 2 or 3 dayes in water, till it be very soft; then mash it in hot water, and beat or work it in large Mortars or Troughs, (much after the manner us'd in some places to Churn Butter) till it be brought to a kind of thin Pap, which must be laid on a Sieve (without pressure,) to drain away the superfluous Moistnes, and afterwards put into warm Water, wherein a good quantity of Fish-Glew or common Size has been dissolv'd. Being thence taken out by parcels with a Sponge, it must therewith (for the Sponge will dry up the superfluous moisture) be press'd into Moulds of Iron, or of such Plaster as Statuaries use, wherein having acquir'd the Figure which is intended to be given it, it is thence to be taken out, and permitted to dry, and is to be strengthened, where need requires, with Plaster, or grated Chalk (made into Pap with Water,) or some other convenient matter; and afterwards, having first been leisurely dried, tis to be either painted or overlaid with foliated Silver or Gold, as the Artist pleases. I may elsewhere have occasion to mention another unlikely use of Paper, namely, to stop the Clefts & Commissures of Wooden Instruments and Vessels, that are to hold Water. For Paper being thrust into these narrow places, the first Water that comes to it being soakt up, occasions a forcible Dilatation, which makes the swelling Paper fill the Chinks tis lodg'd in, according to what was lately deliver'd at the close of the second Section.

The Sugar-Cane has been a Plant well enough known to many Countreys and Ages, who were not unacquainted with the Sweetness of its Juice, and yet seem never to have made Sugar of it, for want of knowing the way of so ordering it, as to coagulate it into a Durable as well as Delicious substance.

Tobacco was likewise a noted Plant in the West-Indies, which was yet suffer'd yearly to rot and perish like other Herbs, till the Industry of the Moderns finding the way of Curing it, (as they call the method of Ordering it) made it, by the help of meer Skill, last in an improved condition for divers Years, and fit to be transported (as it plentifully is) over all the World.

The Leaves likewise of *Indigo*, which would uselessly perish like those of other Shrubs; by the meer way of ordering them, which too is rather by Substraction than Addition, has been long made a lasting Pigment or Dying stuff, and one of the most Staple Merchandises that even the East-Indies send us.

I might add the great Use that we are enabled to make of Madder, Woad, and divers other perishable Plants, by the way of ordering them; but there is one Instance of this kind so considerable, that though I have formerly nam'd it to another purpose, and though I am willing to mention but one Example more of this sort, I cannot but pitch upon this; since it excellently manifests what may be expected from a skilful ordering of Natures Productions, by shewing us, what even the Savages of *America* have been able to perform in this kind. For though their *Mandioca* be confessedly a Poisonous Plant, yet without Addition they make of it their *Cassavi*-Meal, whereof not onely the *Indians*, but also many *Europeans* make their Bread, (which I also have made some use of without dislike.) And with no Addition, unless it be perhaps that of Spittle, they make of the poisonous Juice of the same Root a not unpleasant nor strengthless Drink, which divers even of the *English* compare with our Beer. And of the Bread made of that *Cassavi* Root, they brew, in some of our *American* Colonies, a Liquor by the Planters called *Perino*, which I have known, even by Persons of Quality, equall'd if not preferr'd to Wine it self.

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The Shreds of Leather par'd away and thrown aside by the Glovers, by so slight a way of ordering them, as onely the boyling them long in fair Water, dissolves them in that Liquor, and reduces them with it, the Decoction being strain'd and cool'd, into a kind of Gelly that they call Size, (which may be also made the same way of Cuttings of Parchment, and better yet with those of Vellim,) which is of great use towards the Production of very differing Trades: some of which Productions are already touch'd upon in this Book, to which I shall here onely add, for the easiness of the Experiment, That the fine red Stands, and Hanging-Shelves, are made with ground Vermilion being onely temper'd up with it, and laid upon Wood, which being thus colour'd, is, when it is dry, laid over with common Varnish, which preserves it from Wet, and gives it a Gloss.

It would scarce be suspected that so white a Body as Ivory, should, among other uses, be proper, without the addition of any Black, or so much as dark-colour'd body, to yeld one of the deepest Blacks that has been hitherto known; and yet many of our Eminent Painters count that Black, which they call Ivory-black, the perfectest that hath been hitherto imployed in their Art. And this Sable may be made of Ivory without Addition; onely by burning it a while in a close Pot; and we have made it by keeping it a while among Coals and Ashes, onely wrapt in store of wet Paper to keep it from spending its denigrating Sulphur in an actual Flame; (to prevent which, the Pots, it is burnt in, are wont to be clos'd with Lute, or otherwise sufficiently stop'd,) as if Artificers were acquainted with the old Rule, *Aduſta nigra, perusta alba*

And on this occasion I shall add, That this Black made of Ivory is so excellent in its kind, that I scarce know any thing so proper to make Foils of, for that noblest sort of Gems, Diamonds. And I remember, that a very skilful Jeweller;
of

of whom I bought some of those Stones, and whom I employed to set others for me, confest to me, That burnt Ivory was the thing he made use of, for Foils to the Diamonds he had a mind to set well.

Another Instance there is, which I must by no means pretermitt, now that I am endeavouring to shew, What the Preparation or management of a Body, even by illiterate Tradesmen, may do to make it fit for unlikely Uses. For one would scarce imagine, that from so gross and foul a Body as the *Intestinum rectum* of an Oxe or Cow, there should be obtain'd a transparent Substance, more thin by far than Paper, and yet of so great a firmness and toughness, as is scarce at all credible to those that have not been (as I have) convinc'd of it by Experience. But tis certain that some of our Gold-beaters in *London*, and perhaps not there onely, do, by cleansing and otherwise preparing the above mention'd nasty Gut of an Oxe, obtain exceeding fine Membranes, some of which I keep by me, that though clear and strangely thin, are yet of such tenacity, that when the thin Plates of Gold are put between them, or in their Folds, the force of a man frequently striking them, with a vast Hammer made of purpose, almost as heavy as he can well lift up, does usually, as I have seen with some wonder, attenuate and dilate the included Gold, without being able to break these so fine Skins.

These Instances, *Pyrophilus*, we have hitherto produc'd, are almost all of them such, as either Nature her self, or Nature assisted but by Tradesmen, and other illiterate persons, has presented us. And therefore questionles the Power that a *skilful Management* may have to produce great Changes in Bodies, and thereby fit them for new Uses, will be much advanc'd, when they shall be order'd by such as are either good Chymists, or dexterous at Mechanical and Mathematico-Mechanical Contrivances, especially if in the same Persons a skill in these two sorts of Knowledg should concur.

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That skill in Mathematicks may teach a man so to manage Natural things, as to enable him to make other Uses of them than those that want it will dream of, we may be perswaded by several Particulars. For we see that from a bare giving to a piece of ordinary Glasse a Prismatical shape, that Diaphanous and colourless Body may be made to exhibit in a moment all those delightful and vivid Colours for which we admire the Rainbow; and though meerly by giving a piece of foliated Glasse or Metalline *Speculum* a Concave figure, it may be made to burn strongly by Reflection, yet by giving a piece of Glasse a Convex figure, You may qualifie it to burn by Refraction, and even with Water fitly figur'd You may readily kindle Fire. For though a round and hollow Spherical vial of pure Glasse will transmit the Sun-beams without making them burn, and consequently has not of it self the faculty I am going to name, but serves chiefly to terminate the Water that is to be pour'd into it, and give it its due figuration, yet by filling a Spherical Vial, I have taken pleasure so to unite the Sun-beams, as when Frost and Snow was about me, to make them burn; (and perhaps Ice it self, if chosen free from Bubbles, and conveniently shap'd, may, as some incomplete Tryals make me hope, be made fit enough for that purpose.) And much more vigorous the Accention would be, if two bare Concave Glasses of like shape, equal bigness, and truly ground, had their Edges so join'd by a close Frame, that the Cavity contain'd between the inside of the Glasses and the Frame, may be fill'd with fair water; for by this means (the Convex side of each Glasse being outermost) the whole Instrument (one or two of which I have seen in a *Virtuoso's* hands) will serve for a double Convex Glasse, which may by this means be made far larger, and more efficacious than other Burning-Glasses of that figure, which consisting each of them of a single piece of Solid Glasse, are wont to be far inferior in bigness to such hollow ones,

ones, as may be easily enough attained.

And now I have named Solid Glafs, give me leave to take hence a Rise to adde, That though Glafs stopples are made onely by giving them an almost Conical figure, and a *superficies* fitted by grinding, for an exquisite Contact with the inside of the neck of a Glafs-bottle; yet this way of ordering Glasses, which is ascribed not to meer Philosophers, but men vers'd in Optical and Mechanical Trades, produces Stopples much surpassing all known before; not onely in this, that neither *Aqua fortis*, nor other Corrosive Liquors work upon them, but also in their being able to keep in even the subtlest Spirits so strictly, that I remember having once forgot some Spirit of *Sal Armoniack* in a large Bottle, which it did not neer a quarter fill, when I long after (as I remember about seaven Years) came to that part of *England* again, I chanc'd to find this Bottle in a place, where being without an Inscription, I knew not what the contain'd Liquor was. And taking off the Glafs-stopple, to discover by the scent what it might be, upon smelling to that solid Body, the adherent Spirits operated strongly enough upon my Nose and Eyes to make me almost stagger, and with my Curiosity had been more Cautious.

What I have further observ'd about the way of making, and the Applications of, this kind of Glasses, belongs not to this place, where twould be fit to prosecute my former Discourse by shewing You, How much the Chymical management of things may alter and improve them; were it not that it would be improper to venture upon so copious a Subject in one of the Sections of an Essay, where I shall therefore but point at it, without pretending to treat of it.

We see, that Chymists can out of some Fruits, that grow wild in the Hedges, and are not edible, as also out of the Lees of Ale and Beer, draw an inflammable Spirit, which, for many purposes (not Medicinal,) may be made use of for
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that of Wine. We see that out of the dry Body of Hartshorn, as likewise out of the Skull and Bones of Dead Men, and other Animals, which have been wont to be lookt upon to be so devoid of Moisture, that Men Proverbially say, *as dry as a Bone*, Chymists do ordinarily, to the wonder of the Ignorant, draw store of Spirit, and Oyl, and Flegm, as they likewise do from the dryest Woods. Some of them also, of the opacous Body of Lead mixt with Sand, and a few Grains perhaps of Metalline Pigment, can make in a few hours variety of Amauses or Metalline Stones, which by their Transparency and lovely Colours do pleasingly emulate Rubies, Emeralds, and other native Gems; about the imitation of which, I may elsewhere acquaint You with some of my Trials.

How unlikely Effects may be sometimes produc'd by a slight Spagyric preparation of things, may sufficiently appear by the *Bolanian Stone*, from which (though one would not upon the sight of it expect any such matter, yet) being duely prepared by Chymical Calcination, it acquires that strange Property of *shining in the Dark a while after it has been expos'd to the Sun*, for which it is so justly admir'd by us that have seen it, that tis judg'd unfit to be believ'd by many Criticks that have not.

And here let me take notice to You, *Pyrophilus*, That very slight Circumstances in the Management of a Body may sometimes produce considerable and unlikely Effects.

That Salt, dissolv'd in Water, is a powerful hinderer of the Congelation of that Liquor, is a matter of common Observation; neither the Sea-water, nor Brine, being usually frozen with us by such Frosts as turn common Water, and some Liquors more indispos'd than that is, into Ice: And yet Sea-salt, which being dissolv'd in Water keeps it from freezing, being outwardly applied to Water, does so powerfully concur with Snow or Ice to make it freez in

Artificial Glaciations, and is so necessary to the effect, that the Snow or Ice without the Salt would not ordinarily here in our Climate produce in a seasonable time any Ice at all, as I more than once purposely tried.

There is a certain Powder, which by the Proportion and Mixture of Nitre (whereof it chiefly consists) with other Ingredients, obtains so odd a Texture, that if putting it into a Crucible you should place that upon the Coals, as is usually done in other Fluxes, the Powder would blow up or take fire with violence enough, and perhaps not without some danger; and yet if instead of kindling this Powder from the Bottom upwards, you kindle it from the Top downwards, there will be no danger in it, but it will make a powerful Flux for the reduction of Metalline Powders mixt with it into a Body.

THE V. SECTION.

IN the Vth and last place I consider, That the Generality of Effects to be performed, being not produc'd by one single and unassisted Production either of Nature or of Art, but requiring the Concurrence of More; he that knows not the Nature or Properties of all the other Bodies, wherewith that on which the Experiment propos'd is actually, or may be usefully associated, or otherwise employed, can hardly discern All the Effects the Experiment may possibly concur to produce. For whereas many Inventions or Operations consist as it were of several parts, and require as it were distinct Actions; a Body that seems uselesse to the main and ultimate Effect, may usefully concur to the performance of some intermediate or subordinate part of the Operation, (by being requisite to which, it may be of use to the Experiment consider'd in the Gross, though not to each distinct part of it.)

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Though Spirit of Wine will scarce (if at all) even in a very long time draw a red Tincture out of the Flowers of Sulphur, yet when they have been opened, by having been flux'd together with an equal weight of salt of Tartar, we have found that they will in a few Minutes, and in a gentle heat, give, in thoroughly deflegm'd Spirit of Wine, a Tincture or Solution as red as Bloud; which being freed from the superfluous Menstruum, will afford us a Balsom much finer than that vulgar one, which is wont to be made of the same Flowers dissolv'd in Oyl of Turpentine.

That such Amalgams of Gold and Mercury, as Goldsmiths are wont to guild Silver with, cannot by ordinary wayes be made to adhere either to Iron or Steel, is a thing so well known among Gun-Smiths, and such Artificers as work upon Iron, that when I enquir'd of several of them (as well *Dutch as English*) whether they could guild Iron with Water-Gold, (as they call that way of gilding, by the help of Quick-silver,) they judg'd it a thing not to be done: and yet I know a very Ingenious Tradesman, who was able to perform it, but not (that we may apply this Experiment to our present purpose) without the assistance of another Body, which was to perform one part before the Amalgam could perform the other. The Artificers way was to coat (if I may so speak) the Iron or Steel to be guilt, with a Coat of Copper, to which purpose he us'd distill'd Liquors temper'd with other Ingredients, wherein the Iron was to be immers'd with great wariness and Dexterity; for otherwise not onely the Tryal would not succeed, but oftentimes the Iron would be spoil'd. To obviate which inconveniencies there occur'd another way of Casing the Iron with Copper, namely by dissolving very good Vitriol that has Copper in it (for tis not every Vitriol that is fit for the purpose) in warm Water, till the Liquor be satiated with Vitriol, and immersing several times into this Solution the Iron, first

scoured till it be bright, and suffering it each time to dry of it self; for this Immersion being repeated often enough, there will precipitate upon the Iron enough of the Cupreous parts of the dissolved Vitriol, to fill all its superficial Pores with particles of Copper. So that by this safe, cheap, and easie way, having as it were overlaid your Iron with Copper, you may afterwards guild it as Copper with the above mention'd Amalgam, which will adhere to Copper, though not to Iron.

But here we must not omit an Observation very considerable to our present scope, namely, that though the several parts of an Experiment or a Process, may in most cases each of them be purely Physical, or Chymical, &c. yet in divers other cases it may far more usefully be so order'd, that one part of it may be Physical, (taking here that Term in contradistinction to subordinate parts of Learning) and several or each of the rest may belong to other Arts, as one may be Chymical, and another Statical, another Mechanical, another Hydrostatical, &c. and by such a Concurrence of differing parts of knowledge to the same Operation or Production, I doubt not but many things may be perform'd that have not yet been attempted, nor so much as thought of. For he that has skill but in one of these single parts of Learning, must needs have his Attempts as well as his Knowledge much straitned, by confining himself to operate by such Means and Instrument as are within the compass of his own Art; which assisted by others, may bear a good part in the performance of diverse considerable things, which tis by it self very insufficient to accomplish.

Of this we may take notice of some Instances in the productions that Art and Nature have presented us with already, for not onely Handicraft Trades, as we have formerly noted, do many of them assist each other in their Operations, but even those Arts that are counted ingenious, have sometimes

times need or use both of the service of the more Mechanical Trades, and of mutual Assistance among themselves. The Masters of Catoptricks know very well what would be the Properties of Spherical, Cylindrical, and other *Specula*; but to procure such *Specula* you must have recourse to the Chymist, or the Founder, whose part it is by Artificial Mixtures of Metals and Minerals, and by Mechanical Contrivances, to cast Bodies that give a more sincere and vivid Reflection than the single Metals would do, and to give them withall that curious Polish for which the Metallists and Chymists are beholding to Smiths, Stone-Cutters, Watch-makers, or other Handycrafts men.

Another eminent Example to the same purpose may be taken from the Consideration of Organs us'd in Churches. For to devise the Rules of making them well, there is First requisite no small skill in the Speculative part or Theory of Musick: next, he that would make the Instrument well, must know how to choose Wood proper for that purpose, (most Woods being unfit for it,) *how* to season it, and *how* to discern whether it be duely season'd, and otherwise well condition'd. To excavate and fashion the Pipes, and other parts of the Instrument that are made of this Wood, there is use of the Turners and Joyners Crafts. It is often needful also that the Organ-maker be skill'd in the effects of Metals, and perhaps their Mixtures; and the wayes of Casting them, in order to the making of his Pipes of a Sonorous matter, and to the giving them a due Shape, and other desirable Qualifications. I might here borrow further Instances from Bells, Lutes, Harps, and other Musical Instruments; but I hasten to Examples of another kind.

He that has never so attentively considered the Nature of Salt-petre, or of Brimstone apart, shall never be able to make the considerablest Uses of either of them, till he skillfully associate them to one another, and incorporate them
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into that wonderfull Body call'd Gun-powder, which will afford us an Instance fit enough to explicate what we have been saying: for consisting of three differing Ingredients, Nitre, Brimstone, and Charcoal, though neither of these be sufficient *in omnigere* (as they speak in the Schools,) yet each of them is very useful by being sufficient *in suo genere*, and really concurs to the effect produc'd by them all, as you may elsewhere find more particularly declared.

He must remain ignorant of another considerable use of Sulphur, that is unacquainted with some Properties of common Oyl and calcin'd Alabaster. For Artists have a way of making Moulds, wherein to cast off the Impression of Medals, and other works emboss'd on Metals, which though the Effects of it seem strange to those that know not how they are produc'd, they easily thus perform. They make about the emboss'd work, whose Impression they desire to have, a litle Border or Ledge of Clay, to hinder the melted Sulphur to be poured on it from running over; then they lightly (but very carefully) with a Pencil or Feather anoint the Metalline Work with Oyl, to hinder the Sulphur from adhering to it: then they melt good Brimstone in any convenient Pot, (which they cover well to prevent its taking Fire) and whilst tis hot they pour it gently upon the emboss'd Metal, all whose Extancies will make perfect Impressions on the lower Surface of the thus melted Brimstone, which ought to be poured on in a considerable quantity, that the Moulds thus made may prove the stronger. About the edge of this Mould they make a litle Rimme or Border of Clay as before; and lightly anointing both all the Surface of the Mould and the inside of the Clay with Oyl, (which if it be too copious, is (as we have tried) apt to prejudice the accuratenesse of the Impression,) they pour in by degrees to the thicknesse of about $\frac{1}{4}$ of an Inch of that Mixture I formerly mention'd (in the 8th Essay,) to be made of recently cal-

calcin'd Alabaſter, ſtirr'd and incorporated with ſuch a quantity of fair Water, as may ſuffice to bring it to the conſiſtence of the thicker ſort of Honey. And this Mixture in about a Quarter of an Hour growing hard, and then being taken out of the Mould (to which the Oyl hinders it from ſticking) will, if the work have been dexterouſly done, and the Mixture before Affuſion carefully freed from Bubbles, perfectly exhibit the Shape and Dimensions of the Work Embos'd upon the Metalline Pattern. And by this way in a few Minuts have we ſometimes caſt off a Coyn, a Medal, and ſometimes too a whole Landſcape, without any trouble, and not without ſome delight.

And here, *Pyrophilus*, let me performe what I lately intimated an Intention of, by now taking notice to You in this fifth Section of this Eſſay (of what I had not long ſince occaſion to obſerve in a former part of it,) That You may oftentimes find ſuch particular Bodies conducive to the main Effect of an Operation or Experiment, by performing ſome ſubordinate part or office in it, as yet may ſeem nothing at all of kin to the ultimate Effect promiſed by the perfected Experiment.

That *Aqua fortis*, that ſo greedily corrodes and devours Silver, and Braſs, ſhould eminently conduce to the real Silvering over of the latter Metal by the former, is that which few Goldſmiths, or even Chymiſts would judge probable. And yet this fretting Liquor performs a principal part in that ingenious way of Silvering over Braſſe and Copper, which is more applauded than known. For firſt, *Aqua fortis* ſerves very well to make clean ſuch Embos'd, or otherwiſe uneven pieces of Metal, whoſe Inequality hinders us from being able to cleanſe their little Cavities with Tripoly, or thoſe other Powders commonly uſed to ſcour Braſs: whereas if ſuch Bodies be lightly waſh'd over with *Aqua fortis*, and immediately thrown into fair Water, the Foulneſſe may be fretted

fretted off, and the work not disfigur'd. And this is esteem'd the best way of scouring such Metalline pieces of work by the best Maker of Mathematical Instruments that I have met with. And I the rather mention it to You, *Pyrophilus*, because that though it be not alwaies requisite to our Experiment of Silvering, (for many pieces of Brazen work may well enough be made clean after the ordinary manner) yet divers Trials have assur'd us, that the scouring of the Brass and Copper is necessary to the success of this Experiment; probably because any Grease or Filth remaining upon the surface of the Metal, is sufficient to keep out those little parts of dissolv'd Silver, which ought to lodge themselves so thick in the pores of the Metal, as to seem one continued Silver'd body.

The remaining part of this Operation may be thus perform'd. The Metal to be wrought upon being made very clean, you must dissolve good Silver (the finer the better) in *Aqua fortis* in a broad bottom'd Vessel of Glais, or at least of glaz'd Earth; & having over a Chasing-dish of Coals, or with some such heat, evaporated away all the *Aqua fortis*, you must upon the remaining dry *Calx* pour off Water 5 or 6 times its quantity, or as much as will be needful perfectly to dissolve it. This Water with the like heat must be forc'd away as the former *Menstruum*, and the like quantity of fresh water must be pour'd on, and evaporated quite away the second time, and if need be the 3^d time, toward the later end making the Fire so strong as to leave a perfectly dry *Calx*, which, if your Silver has been good, will be of a good White, and will by these Operations be competently freed from the stinking and fretting Spirits of the *Aqua fortis*. Of this *Calx* you must take one part, and about as much (in Quantity, not in Weight) of common Salt, and as much of Chrystals of Tartar (or at least Powder of good white Tartar) as of either of the former Ingredients; which, like
this

this, ought to be finely beaten, and these three Powders being exquisitely mixt, you must plunge the scour'd Brasse, to be silver'd over, into fair Water; and then taking up as often as need requires with your wet fingers some of the newly mention'd Mixture, you must rub it on well till you find every little Cavity of the Metal sufficiently silver'd over; remembering, that if you would have it richly done, you must rub in more of the Powder. And last of all, you must wash well your silver'd Metal in fair water, and rub it very well, and hard with a dry Cloath, that it may appear smooth and bright. And this way of Silvering, though it be presently and cheaply perform'd without Quick-silver, yet may be made to last some Years, as Experience has partly inform'd me, and may be easily renewed when the Silvering begins to decay or wear off.

And here *Pyr.* it will not be improper to give You this Advertisement. That we ought not to conclude, as we are very prone to doe, that such an Use is not to be expected, or endeavour'd to be obtain'd from such a thing, because we see the like Use to be made of things that are thought to be of a quite differing nature from that we consider, or perhaps quite contrary to it: for in many cases, as there are more wayes than *one*, or even than a *few*, to bring to passe a thing propos'd; so among the various Instruments that may be employ'd the same purpose, some may exceedingly differ between themselves as to other Qualities, and yet agree in that which is requisite and sufficient for the performance of the thing design'd. As though, for Instance, Rosin and Sal Armoniack be differing in Colour, Smell, Taste, Weight, Hardnesse, &c. though the one be a vegetable concrete juice, the other an aggregate of Urinous, Fuliginous, and Marine Salts; the one readily dissoluble in water, the other not dissoluble in that Liquor, but in Oyl; and though there be I know not how many other differences between them; yet

either of them single may be, and is, usefully employ'd for the Tinning of Brassie and Copper-vessels, each of them being endowed with a fittest to make Tin stick to those Metals, (as I elsewhere more particularly declare.) Thus, though Water, Sand, and Tin, are bodies in other respects very unlike, yet the two later are found fit to make Hour-glasses, as well as the first; though that alone, as is presum'd, were for many Ages employ'd by the Ancients for that purpose.

To the foregoing Advertisement I shall annex another, that may seem very differing from it, but yet is no lesse true; namely, that we are not alwayes to suppose, that because a Natural Body has such an Use on some occasions, the same Body cannot on other occasions be employed to Uses that seem of a quite differing, and perhaps of an opposite nature.

This I conceive may be done principally by these two wayes. First by the differing Constitutions of the severall Bodies the same Agent works upon; as when the heat of the Sun melts Wax and hardens Clay; and the same spirit of Vinegar, which on filings of Copper will by Digestion obtain an abominable Taste, will upon filings of Lead acquire by the same way a very great Sweetnesse: and spirit of Salt that will dissolve Copper and Iron, as *Aqua fortis* also does, will yet precipitate Silver dissolv'd in that Menstruum, And to this first way I shall subjoyn the *second*, which is, that such a parcel of Matter, as is wont to be consider'd as one and the same Body, may contain in it parts of very differing natures, upon whose account its Operations may be diversified. Thus when we calcine some unripe Minerals with Nitre, the inflammable parts of the Nitre do burn up and dissipate into smoak the volatile and combustible parts of the Mineral; but by virtue of the remaining Alcali of the Nitre, several other parts of the Mineral are made far more fixt and capable of enduring the fire, than they were before. So Sulphur has in it some parts that make it more readily inflam-

inflammable than even Nitre or Oyl ; and yet it abounds with acid and vitriolate particles that are not inflammable themselves, and much resist the Accension of Flame in divers other Bodies. And accordingly, though in Matches us'd in Tinder-boxes to take fire readily, the kindled Brimstone acts upon the shivers of Wood, whose ends were crufted over with it, as an ordinary flame; yet the same burning body, by virtue of its acid parts, works in another capacity, than that of a common flame upon some Metals, especially Iron, and likewise upon the Leaves of red Roses, which its Fumes turn white.

I could, if it were needful, propose in this place, sundry other Instances of the differing actions of the differing parts of a Body, and could likewise subjoyn other Cases, than I have yet mention'd, wherein Bodies may be applied to uses that many would be unapt to expect from them. But judging it more convenient to reserve those for other places, especially in the last Essay, I shall conclude this with the two following Advertisements.

The first is, That I have in all this Discourse purposely forborn to treat of the Medicinal uses of things, because my scope in the Volume, whereof this Essay is a part, oblig'd me so to do. But yet I am sensible, and would have you so too, that hereby I have forborn to employ a multitude of particulars, that would have much enrich'd this Treatise. For there is a great number of Bodies both Natural and Facitious, that being employ'd as Medicines for humane Bodies, have there very various and sometimes seemingly repugnant Operations, many of which would serve to illustrate and confirm sundry passages of this Essay. Thus Rhubarb, whether taken in Substance or Infusion, does by virtue of its differing parts, first purge and then bind. Spirit of Wine taken inwardly, exceedingly heats the Body, whereas outwardly tis employ'd to appease the heat caus'd by some hot humors

and inflammations. Mercury taken inwardly crude as it is, has often, though not alwayes, prov'd an effectual and harmeles Medicine in Worms, and some other Distempers, even to Children and Women in Labour: but the same Mercury rarified into fumes, (which yet may be condens'd again into running Mercury,) and in that form taken into the body, does too often cause vehement and dangerous commotions in the juices of the Body, as excessive Salivations, Fluxes, &c. declare. And he that shall attentively consider the various operations of that one Mineral Antimony, and the not onely differing, but oftentimes contrary Effects that it produces, according to the Complexions and Dispositions of the Taker's body, and the Preparation of the Mineral it self, will not, I presume, stick to allow me, That the Medicinal uses of things, if I had not thought fit to decline them in this Essay, might have much increas'd the number of Instances it contains; the effects of other Bodies upon those of Men being no less proper Instances of Natures wayes of working, than the changes they produce, when they work onely upon one another.

The second Advertisement (wherewith I shall conclude this Essay) is, That though what I have hitherto discours'd, hath almost solely related to the neglected uses of particular Natural Bodies: yet I would not have You thence take occasion to imagine, that there are not other Natural things whereof divers Uses may be made, that men have hitherto either ignor'd, or overseen. By *other Natural things* I mean *the differing states of Matter, or of Bodies,* (such as Rarity and Density, Fluidity and Firmness, Putrefaction and Fermentation, may seem to be,) as also *the more operative qualities, such as Heat, Cold, Gravity, &c. the Laws of Local Motion among the parts of Matter, and the present Fabrick of the Universe, and especially that of our Terrestrial Globe and its Effluvia,* to which might be added other things in Nature, that are not properly *Bodies* in the usual sense of that word, but may be called *Things Corporeal* as they belong to Bodies, and entirely depend on them. In favour of this Advertisement twere easie for me to suggest to You such a multitude of Particulars, that reserving some few for the last Essay, I here purposely forbear to mention any at all, to avoid being entic'd or engag'd to enter upon a subject, that could not be otherwise than very lamely handled, without enormously swelling an Essay, that does already exceed its just Dimensions.

